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The guide has been revised to accommodate the adoption of "Physical Science Study Committee College Physics" as the basic textbook for this course. An introduction describes the scope and objectives of the course. Presented are suggestions for teaching the course, content, time allotment to topics, laboratory work, evaluation, materials and equipment, and use of community resources. Topics included in the course are discussed under the headings of "Optics and Waves," "Mechanics," and "Electricity and Atomic Structure." Appendices include suggestions for individual study, books, periodicals, and equipment. (BC)

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GUIDE FOR TEACHING HONORS PHYSICS 1-2

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San Diego City Schools
San Diego, California
1968

GUIDE FOR TEACHING HONORS PHYSICS 1-2

GRADE 12

Prepared by

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San Diego City Schools
San Diego, California
1955

Fifth Edition: 1968
Unedited

PREFACE

This fifth edition of the Guide for Teaching Honors Physics 1-2 is a major revision of the former publication to accomodate the adoption of the Physical Science Study Committee College Physics: as the basic textbook material for the course.

It is expected that the honors course will be offered in San Diego City schools concurrently with other regular physics courses such as the PSSC Physics and the Harvard Project Physics. Materials for these courses are also referred to in the guide.

The publication is tentative and has not been edited. It will be used and evaluated by the teachers involved. Submission of constructive suggestions for its improvement are solicited and should be sent to the Science Specialist, Curriculum Services Division.

Wm. H. Stegeman
William H. Stegeman
Assistant Superintendent
Curriculum Services Division

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INTRODUCTION

Description of Course*

HONORS PHYSICS 1-2 (two-semester course--grade 12--prerequisites: successful completion or concurrent enrollment in "Trigonometry and Advanced Algebra 1-2" or a higher level mathematics course, superior academic standing; see District Procedure No. 5436-1)

Description of course:

The course content is similar to the regular course in physics, with a greater emphasis on modern physics. The laboratory approach of the Physical Science Study Committee is used in this course along with appropriate supplementary college-level materials.

Objectives of course:

The objectives of this higher level course in physics are essentially the same as stated for Physics 1-2 except that the greater opportunities for depth study and coverage of more advanced topics should result in great individual accomplishment in original problem solving, technical writing, and possible qualification for advanced placement in college through examination.

Instructional content or areas of emphasis:

Introduction	1-2 weeks
Optics and Waves	9-10 weeks
Mechanics	14-15 weeks
Electricity and Atomic Structure	10-11 weeks

Basic texts: Physical Science Study Committee, College Physics, 1968
Physical Science Study Committee, College Physics Laboratory Guide, 1968

Supplementary texts: White and Manning, Experimental College Physics, 3rd ed., 1954 (Laboratory Manual)
White, Modern College Physics, 5th ed., 1966

Guides: San Diego City Schools, Guide for Teaching Honors Physics 1-2, 1968 (Stock No. 41-P-6600)
Physical Science Study Committee, Instructors Guide for College Physics, 1968
San Diego City Schools, Handbook of Science Laboratory Practices and Safety, 1966

*San Diego City Schools Digest of Secondary Schools Curriculum, published annually, San Diego, California

Objectives

This course is frequently the student's first introduction to the formal study of physics. It is not expected that he will emerge an expert in this vast area of science. Keeping this in mind, the teacher should seek to do the following:

- Stimulate intellectual curiosity, engender satisfaction in intellectual achievement, and cultivate the ability to think rationally.
- Help the student develop an appreciation of ethical values which form the basis of life in a democracy and of the responsibilities and contributions of science to society.
- Provide the student with a frame of reference in which may be shown how knowledge is obtained experimentally and how the results can produce a theory through the application of the scientific method.
- Develop skills in the use of specific instruments and tools as required by the course.
- Demonstrate the application of mathematics as a tool in problem solving. The mathematics involved will include trigonometry and elementary calculus, along with the use of logarithms and the slide rule.
- Teach the use of graphing techniques for the correlation of experimental data from which empirical mathematical relationships may be developed.
- Give instruction in effective communication with written and oral reports, including vocational opportunities in physics.

Scope

The content of the Physical Science Study Committee (PSSC) college-level course has been chosen "not simply to cover physics, but to display the structure of the field." The topics which have been selected are explored more fully than in other beginning physics courses. Where desired, the teacher is encouraged to present a broader topical coverage by reference to supplementary materials which are available in our schools, such as White's Modern College Physics. To achieve a basic understanding of the conceptual framework of modern physics, the student is expected to:

- Study his PSSC texts and other materials provided.
- Use a more rigorous approach to the mathematical derivations as obtained from experimental physical data.
- Intelligently evaluate and understand physical problems through the application of basic principles of physics.
- Participate in laboratory investigations which involve independent thinking along with a mature analysis of collected data.
- Extend beyond the classroom his interest in physics by studying and doing research in areas which are not covered in the course. These student projects frequently become entries in the Greater San Diego Science Fair.

SUGGESTIONS FOR TEACHING

Course Content

It is the intention of this course to teach what physics is and to reveal its structure content. Most of the topics listed in the guide follow a sequential pattern and are all interdependent. The outline is intended as a guide in the selection of topics to be studied and in this context there will be found listed:

- Subject matter topics covered in the PSSC course in physics.
- Laboratory experiments which are normally done in each area of study.
- Films, texts, outside reading, and other references.

The subject matter topics are coded to the PSSC text, College Physics, which is the basic textbook for the course, and to Modern College Physics, 5th ed., which serves as a supplementary textbook. Other references may also be brought in wherever the teacher feels that they are appropriate.

The laboratory experiments are coded to the PSSC College Physics Laboratory Guide. References are also made to White and Manning's Experimental College Physics and to other sources which are specifically noted.

The visual aids have been selected to correlate with the topical outline. The type of aid is indicated along with running time or, in the case of film strips, with the number of frames.

The selections listed under "Outside Reading" are particularly suited to the topics in the guide. The student should be encouraged to consider these references as an integral part of the course, and reading assignments should be made by the teacher.

In addition to using the above instructional resources, the student is expected to participate in other experiences such as:

- Library work on special topics.
- Science projects or research.
- Field trips and listening to guest lecturers.
- Competitions in physics such as the annual NELC and NAPT exams.
- Student-built scientific equipment and apparatus.

Sequence of Topics and Time Allotment

The topic outline follows the PSSC course. For uniformity among the schools, it is recommended that the units "Introduction," "Optics and Waves," and "Mechanics" through Topic Outline 16 be covered during the first semester. The remainder of "Mechanics" and "Electricity and Atomic Structure" should be covered during the second semester.

Time allotment for each unit is not rigid but the following allocation of time is suggested:

SEMESTER I

Introduction, Topic Outlines 1-2, 1-2 weeks.

Optics and Waves, Topic Outlines 3-10, 9-10 weeks.

Mechanics, Topic Outlines 11-16, 7 weeks.

SEMESTER II

Mechanics, Topic Outlines 17-23, 7-8 weeks.

Electricity and Atomic Structure, Topic Outlines 23-36, 10-11 weeks.

Laboratory Work and Equipment

A list of suitable laboratory experiments related to course topics is a part of the topic outline. It is expected that the student will perform, on the average, at least one laboratory experiment per week. The activities listed have been taken from the PSSC College Physics Laboratory Guide, White and Manning's Experimental Physics, 3rd ed., and from other sources which will be duly noted. The choice of experiments has been made to provide the students with the following opportunities:

- To learn by means of actual observation some of the principles of physics.
- To do some independent thinking.
- To become familiar with modern measuring equipment.
- To learn the fundamentals of preparing a technical report on the results of a scientific study, the report to include critical analysis and clear presentation of the experimental results in graphical form, where possible, and as an algebraic statement.

Some of the experiments involve the use of equipment not available to each individual school. In order to conserve funds and storage space, the necessary equipment as listed in Appendix B will be made available on a circulating basis to be shared by the schools in each of three area "circuits" as follows:

East: Crawford, Lincoln, Morse, and Patrick Henry High Schools.
Central: Kearny, Hoover, Madison, and Clairemont High Schools.
West: La Jolla, Mission Bay, San Diego, and Pt. Loma High Schools.

Each teacher should arrange to pick up the equipment from one of the other schools on his circuit. At the end of the school year, the equipment is to be returned to the school responsible for its inventory control.

Conventional Usage

Since the mks system of units is rapidly replacing the cgs system, emphasis on the use of the newer system should be made throughout the course. A table of mks units and conversion factors will be made available to each student. It is recommended that the use of letter symbols and abbreviations follow those in the text.

Student Preparation

Students will be expected to spend approximately one hour in preparation for each class session. Reading and problem assignments should be made from the textbooks and laboratory manuals. Students should be encouraged to use the slide rule wherever possible in making their calculations.

Use of Community Resources

Special lectures and seminars will be arranged in cooperation with community agencies interested in the science education for the able student. Current lists of available speakers are maintained for the convenience of the teacher.

Naval Electronics Laboratory Center Science Achievement Awards

This is an annual competition open to the students of honors physics. Details of this program involving both team and individual competitions are announced in November. The exams and the awards program are normally held in April.

Evaluation of Student Progress

Evaluation of student progress should be in terms of the objectives of the course. The PSSC tests which parallel the development of the course serve as an excellent vehicle for evaluation of student achievement. The teacher is urged to make the various forms of these exams available to his students. Tests may be obtained from Testing Services, San Diego City Schools. Request: Tests of the PHYSICAL SCIENCE STUDY COMMITTEE.

The College Entrance Examination Board Pamphlet, "Achievement Tests"¹ contains an excellent discussion of test development and examples of test items.

Meetings of Teachers

Meetings of teachers of honors courses are held at stated intervals during the year for "in-service" training through demonstration of new equipment and materials, and to discuss:

- Annual plans.
- Techniques of instruction.
- Evaluation of the course.
- Future development of the course.
- Special activities for students.

Materials and Equipment

In Appendix B are listed recommendations concerning:

- Books and supplies on a one-per-pupil basis.
- Books and materials for classroom reference.
- Books which should be available in the library.
- Laboratory equipment available on circulating basis.

¹ College Entrance Examination Board. "Achievement Tests," latest edition. Los Angeles, California: Education Testing Service.

TOPIC OUTLINES

I. Introduction	12
II. Optics and Waves	14
III. Mechanics	22
IV. Electricity and Atomic Structure	34

Key to Abbreviations Used in the Topic Outline

Ch. - Chapter

EBF - Encyclopedia Britannica Film

ECP - Experimental College Physics

Fs - Filmstrip

HPP - Harvard Project Physics

McGH - McGraw Hill Co.

MCP - Modern College Physics

CPPSSC - College Physics Physical Science Study
Committee

CPLG - College Physics Laboratory Guide

I. Introduction

1. TIME, SPACE AND MATTER (3 days)	INSTRUCTIONAL RESOURCES
<u>The tools of physics</u> -Microscope -Telescope -Laboratory balance -Seismograph -Cyclotron, etc. <u>The people of physics</u> -Scientists -Engineers -Artists, designers, and others -Electricians, etc. <u>Time and its measurement</u> -Short time intervals -Repetitive motions, the stroboscope -Comparing times and counting units -Large and small times <u>Space and its measurement</u> <u>Matter</u> <u>Limitations of measuring</u> <u>Fractional error</u> <u>Black boxes</u>	TEXTS Basic: CPPSSC CH. 1 Supplementary: MCP Ch. 1, 2 LABORATORY CPLG: Exp. 1 Exp. 2 Exp. 3 ECP Exp. Ch. 2, Sig Figures etc; and Ch. 3, Sec. 1. Vernier and micrometer devices. VISUAL AIDS <u>Films:</u> Short Time Intervals, PSSC (21) Time and Clocks, PSSC (28) Long Time Intervals (21), PSSC About Time; Parts I and II, A-T-T- (60) The Micrometer, USDE (15) Measuring Large Distances, PSSC (29) Measuring Short Distances, PSSC (20) <u>Programmed Lesson:</u> HPP, Measurement and Precision <u>SP-L 759-9492</u> The Starry Night OUTSIDE READING "Time Reversal," <u>Scientific American</u>, Vol. 196, Feb. 1957, p. 10. Carnap, Rudolph. "Merits of the Quantitative Method" from: <u>Philosophical Foundations of Physics</u>, Basic Books Inc., N.Y., 1966, Ch. 11. Holton, Gerald. "The Nature of Concepts" from: <u>Introduction to Concepts and Theories in Physical Science</u>, Addison-Wesley, Reading, Mass., 1952.

I. Introduction (Cont.)

2. DATA, GRAPHS AND FUNCTIONS (4 days)

INSTRUCTIONAL RESOURCES

Tables and graphs

- Tabulation of data
- Graphical representation of data
- Analysis and formulation

Direct proportion and linear function

Power laws and similar figures

- Areas and volumes as examples of second and third power laws.
- Derivation of tables, graphs, and equations of these power laws.

The inverse-square relation and stellar distances

- Light intensity as a function of distance.
- Measuring relative intensity of a light source, using the inverse relationship.
- Light intensity as used in measuring star distances.
- Limitations of this method.

The exponential function

- Validity and limitations
- Validity and significance
- Exponential function and semi-log plots
- Power laws and log-log plots

Scaling - The Physics of Lilliput

- Relationship between strength and C.S. area.
- Surface area and linear dimensions
- Load versus strength problems in scaling up.
- Changes in behavior in systems which are scaled up or down.

TEXTS

Basic: CPPSSC, Ch. 2
Supplementary: ECP, Ch. 1

LABORATORY

CPLG, Exp. 4 and Exp. 5

VISUAL AIDS

SP-L 759 The Cocks
Film:
Change of Scale, PSSC (23)

OUTSIDE READING

Dole, Stephen H. "An Appreciation of the Earth" from: Habitable Planets for Man, Blaisdell Pub. Co., Division of Ginn and Co., N.Y., 1964.

II. Optics and Waves

3. THE PROPAGATION OF LIGHT (4 days)	INSTRUCTIONAL RESOURCES
<u>Sources of light</u> -Propagation of light -Identification of sources of light <u>Interaction of light with matter</u> -The behavior of light in striking an object -The transmission of light -Transparent, colored and opaque objects <u>Reflection of light</u> -Light-sensitive objects -Relative sensitivity of objects to light -Some devices which can measure relative light intensities -Invisible light <u>How light travels</u> -Light travels in straight lines; rectilinear propagation -The bending of light -Diffraction -Propagation of light, its nature and speed -Location of objects	TEXT Basic: CPSSC, Ch. 3 Supplementary: MCP, Ch. 36 LABORATORY ECP, Ch. 39, Section 39.1 VISUAL AIDS Film: Nature of Light, Coronet (11) OUTSIDE READING Young, Thomas. "Experiments and Calculations Relative to Physical Optics" from: <u>Miscellaneous Works of Thomas Young, Vol. 1</u>, edited by Geo. Peacock and John Murray, London, 1855, Ch. 9. Michelson, A.A. "Velocity of Light" from: <u>Studies in Optics</u>, The University of Chicago Press, Chicago, 1927.

II. Optics and Waves (Cont.)

4. REFLECTION AND REFRACTION (5 days)

INSTRUCTIONAL RESOURCES

The ray diagram as a technique in understanding light behavior.

- Formation of shadows.
- Light rays and what they represent.
- The non-interaction of light rays.

The two laws of reflection.

- The incident and reflected ray and their plane of interaction.
- The angle of reflection compared to the angle of incidence.

Image formation in plane mirrors.

- Description of an image.
- Location of an image.
- The geometry involved in image location and size.
- Multiple images and their formation.

The incident ray, the refracted ray, and the normal; their relationship.

- Experimental evidence for refraction.
- Evaluation of experimental data on refraction.

The index of refraction, Snell's Law.

- Relationship between the angle of refraction and the angle of incidence.
- The absolute index of refraction.
- Methods of representing this relationship.

The reversibility of light and refraction.

- Passage of light from glass, water to air.
- Passage of light from water to glass.
- Total internal reflection.

Dispersion.

- Refraction with prisms.
- Composition of white light.
- Index of refraction as related to wavelength.
- The prediction of light path through a prism, using Snell's law.

TEXTS

Basic: CPPSSC Ch. 4
Supplementary: MCP Ch. 37, 38 and 39

LABORATORY

CPLG, Exp. 6 and Exp. 7

ECP, Ch. 40, Section 40.2, Part I

VISUAL AIDS

Fs 535 Light

OUTSIDE READING

Griffin, Donald R. "Echoes of Bars and Men" from: Science Study Series, Doubleday Anchor 1959.

Minnaert, M. Light and Color in the Open Air, Dover, 1954.

II. Optics and Waves (Cont.)

5. THE PARTICLE MODEL OF LIGHT (4 days)	INSTRUCTIONAL RESOURCES
<u>Reflection and the particle model.</u> -The two laws of reflection. -Ideal elastic collisions and the two laws of reflection. -Specular and diffuse reflection and the model particle. <u>Refraction and the particle model.</u> -The two laws of refraction and the particle model. -Limitations of the particle model. -Implications for refraction. <u>Inverse square law and the particle model.</u> -The unit of light intensity. -Explanation of the inverse square law by the particle model. <u>Pressure of light; prediction by the particle model.</u> <u>Particle model and the absorption and heating of light.</u> <u>The limitations of the particle model.</u> -Partial refraction and reflection. -Diffraction. -Limited value of a complicated model. -The speed of light and the particle model.	TEXTS Basic: CPPSSC, Ch. 5 LABORATORY CPLG, Exp. 8 VISUAL AIDS Films: The Pressure of Light, PSSC21 The Speed of Light, PSSC (23) OUTSIDE READING Jaffe, Bernard. "Michelson and Speed of Light" from: <u>Science Study Series, Double-day Anchor, 1960, Ch. 3.</u> Maggie, William Francis. <u>A Source Book in Physics.</u> McGraw Hill, 1935.

II. Optics and Waves (Cont.)

6. INTRODUCTION TO WAVES (3 days)

INSTRUCTIONAL RESOURCES

Characteristics of a wave

- The disturbance of a "medium"
- Propagation
- Transportation
- Pulses

Waves on a coil spring

- Speed of a pulse
- Motion of a point versus the motion of a wave
- Graphing a pulse
- Superposition

Reflection and transmission

- Fixed-end reflection
- Free-end reflection
- Transmission in various media
- Idealization and approximations in the evaluation of pulses

The wave model of light

TEXTS

Basic: CPPSSC, Ch. 6

LABORATORY

CPLG: Exp. 9

VISUAL AIDS

Film:

Simple Waves, Bell Telephone (27)

Demonstration: Bell Telephone Wave Machine (40)

OUTSIDE READING

Maxwell, James Clark. "Action at a Distance" from: Scientific Papers of James Clark Maxwell, Vol. II, Cambridge University Press, Cambridge, England.

PSSC: "Introduction to Physics" from: Physics, D.C. Heath, Boston, 1965, Ch. 15.

Lindsay, Robert Bruce. "Wave Motion and Acoustics" from: General Physics for Students of Science, John Wiley and Sons, Inc., N.Y., 1940, Ch. 26.

II. Optics and Waves (Cont.)

7. WAVES AND LIGHT (10 days)	INSTRUCTIONAL RESOURCES
<u>Water waves.</u> -Straight and circular pulses, their direction of propagation. -Reflection of water waves. -Crests and troughs. -Water waves and the law of reflection. <u>The speed of propagation of a wave.</u> -Periodic waves. -Frequency and period. -Wavelength uniform speed and period. -Speed as a function of wavelength and period. <u>Refraction and waves.</u> -Water waves and Snell's Law. -Speed of a water wave dependent upon the depth of water. -Index of refraction and the wave model. -Reflection and refraction at the boundary between two depths of water. <u>Dispersion.</u> -Dispersion and the frequency of a wave. -Different frequencies and color. <u>Diffraction.</u> -Definition. -Relationship between wavelength and slit opening. -Prediction of the wavelength of light.	TEXTS Basic: CPPSSC, Ch. 7 Supplementary: MCP, Ch. 42 and Ch. 43 LABORATORY CPLG, Exp. 10 Exp. 11 Exp. 12 Exp. 13 VISUAL AIDS Demonstration: Sunset Film: Spectograph, McGraw Hill (20) OUTSIDE READING Benade, Arthur H. "Horns, String and Harmony," <u>Science Study Series</u>. Doubleday Anchor, 1960, Ch. 2 and Ch. 4. Bonner, Francis T. and Phillip Melba, <u>Principles of Physical Science</u>, Addison Wesley, 1957, Ch. 16.

II. Optics and Waves (Cont.)

8. INTERFERENCE (5 days)

INSTRUCTIONAL RESOURCES

Periodic waves in one dimension.

- Interference on a spring.
- Reflection, refraction, and diffraction and the wave model.
- Nodes and interference.

Two-dimensional waves.

- Two-point source of waves.
- Nodal lines and their significance.

Wavelength, source separation, and angles.

- Calculating and interference pattern at a large distance from the source.
- Phases of a wave.
- Effect of "out-of-phase" sources on an interference pattern.

TEXTS

Basic: CPPSSC, Ch. 8
Supplementary: MCP, Ch. 44

LABORATORY

CPLG: Exp. 14
Exp. 15

VISUAL AIDS

Film:
Sound Waves in Air, PSSC, (35)

OUTSIDE READING

Lindsay, Robert Bruce, "Wave Motion and Acoustics" from: General Physics for Students of Science. John Wiley and Sons, Inc., N.Y., 1940.

Benade, Arthur H. "Ears, Architects of Harmony" from: Horns, Strings and Harmony. Doubleday and Co. 1940, Ch. 5.

II. Optics and Waves (Cont.)

9. LIGHT WAVES (10 days)	INSTRUCTIONAL RESOURCES
<u>Physical factor related to interference.</u> -Interference patterns and the ripple tank. -Nodal lines and wavelength. -Measuring the wavelength. <u>Two-slit interference.</u> -Two-light sources in phase. -Phase of light sources and interference patterns. -Lasers. <u>Color and wavelength of light.</u> -White light and interference. -Wavelength of the spectral colors in white light. <u>Diffraction.</u> -Superposition. -Huygen's principle. -Diffraction by a slit. -Diffraction and resolution. <u>Interference in thin films.</u> -Two surfaces of a thin film and reflection. -Reflected light and interference. -Interference and transmitted light through thin films. -Color effects in interference.	TEXTS Basic: CPPSSC, Ch. 9 Supplementary: MCP, Ch. 43 Ch. 44 Ch. 45 LABORATORY CPLG: Exp. 16 Exp. 17 Exp. 18 VISUAL AIDS Fs Ripple Tank and Waves (36) OUTSIDE READING Mack, J. E. and Martin, M. J. <u>The Photographic Process.</u> McGraw-Hill Book Co., 1939. Weisskopf, Victor F. <u>Knowledge and Wonder.</u> Doubleday Anchor 1963, Science Study Series Ch. 3 and Ch. 9.

II. Optics and Waves (Cont.)

10. APPLIED OPTICS (6 days)

INSTRUCTIONAL RESOURCES

Curved mirrors.

- Curved mirrors and light focusing.
- Laws of reflection and curved mirrors.
- Parallel light rays and their behavior in reflection.
- Definition of and location of principle focus.

The reversibility of light.

- Definition of focal length.
- The searchlight and astronomical telescope and their use.
- The convergence of light by a set of prisms.

Lenses.

- Converging-diverging lenses.
- Image formation.
- Conjugate foci; lens maker's formula.

Image formation with parabolic mirrors.

- Ray diagrams.
- The light ray through the principal focus and its behavior.
- The geometry involved in reflection.
- Image position and size.
- Real and virtual images.

Optical instruments.

- The magnifier or simple microscope.
- The compound microscope.
- Refracting telescopes.
- Limitations of optical instruments.
- Abberations and resolutions.

TEXTS

Basic: CPPSSC, Ch. 10

Supplementary: MCP, Ch. 39
Ch. 40
Ch. 41

LABORATORY

CPLG: Exp. 19
Exp. 20
Exp. 21
Exp. 22

ECP, Ch. 41

VISUAL AIDS

Films:

Introduction to Optics,
PSSC (23)

Spherical Mirrors EBF (13)

OUTSIDE READING

Jenkins, Francis A. and White,
Harvey E. Fundamental of Optic.
McGraw Hill, 1957, Chs. 4,
5, 9, and 10.

Newton, Sir Isaac, Optics.
4th Ed. of 1730, Dover
Pub. Co., N.Y., 1952.

III. Mechanics

11. MOTION ALONG A STRAIGHT LINE PATH (5 days)	INSTRUCTIONAL RESOURCES
<u>Position and displacement along a line.</u>	TEXTS
-Coordinate system. -Negative and positive displacements.	Basic: CPPSSC, Ch. 11
<u>Velocity.</u>	Supplementary: MCP, Ch. 3 Ch. 4
-Constant velocity. -Varying velocity.	LABORATORY
<u>Position-time graphs.</u>	CPLG: Exp. 23 Exp. 24
-Analysis for a steady velocity. -Analysis for a varying velocity. -Slope of a line and its significance. -Slope of a tangent line and instantaneous velocity.	VISUAL AIDS
<u>Velocity-time graphs.</u>	Program lesson on displacement and position--HPP.
-Acceleration as interpreted from velocity-time graphs. -Results for motion with constant acceleration.	

III. Mechanics (Cont.)

12. MOTION IN SPACE (4 days)

INSTRUCTIONAL RESOURCES

Position and displacement.

-Addition and subtraction of displacements.

-Multiplying vectors by numbers and scalars.

Velocity vectors in space.

-Compounds of vectors.

Velocity changes and constant vector acceleration.

Changing acceleration.

Description of motion.

-Frames of reference.

Kinematics and dynamics.

Speed of light.

TEXTS

Basic: CPPSSC, Ch. 12

Supplementary: MCP, Ch. 7
Ch. 8
Ch. 12

LABORATORY

CPLG, Exp. 25

VISUAL AIDS

Programmed lesson in vectors--HPP.

III. Mechanics (Cont.)

13. NEWTON'S LAW OF MOTION (5 days)	INSTRUCTIONAL RESOURCES
<u>Ideas about force and motion.</u> -Force related to push or pull. -Net force and changes in motion. -Motion without force. <u>Changes in velocity.</u> -Constant force. -Changes in velocity and applied force. <u>Mass and weight.</u> -Inertial mass. -Inertial mass and gravitational mass. <u>Newton's Law of motion.</u> -The unit of force. -Changing forces and Newton's Law. -Addition of forces and net force. -Vector nature of Newton's Law. -Forces in nature.	TEXTS Basic: CPPSSC, Ch. 13 Supplementary: MCP, Ch. 6 LABORATORY CPLG: Exp. 26 VISUAL AIDS Films: - Forces, PSSC (22) - Inertia, PSSC (27) - Inertial Mass, PSSC (20) OUTSIDE READING Murchie, Guy. <u>Music of the Spheres</u>, Houghton Mifflin, 1960, Ch. 10. Galileo, Galilei. <u>Dialogues Concerning Two New Sciences</u>, translated by H. Crew and A. de Salvio. Macmillan, 1914.

III. Mechanics (Cont.)

14. MOTION AT THE EARTH'S SURFACE (7 days)

INSTRUCTIONAL RESOURCES

Weight and the "gravitational field."

- The meaning of weight.
- Relationship between mass and weight.
- Weight of an object at the earth's surface.

Falling bodies.

- Gravitation.
- Free fall.
- Acceleration due to gravity.
- Air resistance.
- Terminal velocity.

Projectiles.

- Vertical and horizontal motion.
- Horizontal motion and constant velocity.
- Vector nature of Newton's Law of motion.
- Trajectory.

Constant force and instantaneous motion.

- A constant force perpendicular to the motion.
- Circular motion.
- Kinematics of circular motion.
- Satellite motion, artificial and natural.

Simple harmonic motion.

- Restoring force and displacement.
- Centripetal force and its components.
- Harmonic motion and Newton's Law.

Frames of reference.

- Experimental frames of reference.
- Inertial frame of reference.
- Accelerating frames of reference.
- Fictitious forces and accelerated frames of reference.
- Newton's Law and the earth's rotation.

TEXTS

Basic: CPPSSC, Ch. 14

Supplementary: MCP, Ch. 5
Ch. 6

LABORATORY

CPLG: Exp. 27
Exp. 28
Exp. 29

ECP, Ch. 6, Section 6.1

Free Fall, Polaroid and Strobe

VISUAL AIDS

Films:

Falling Bodies, PSSC (30)
Deflecting Forces, PSSC (29)
Periodic Motion, PSSC (30)
Frames of Reference, PSSC (26)

OUTSIDE READING

Faraday, Michael. "The Force of Gravity," from: On the Various Forces of Nature. Viking Press, N.Y. 1960.

Dicke, R. N., Roll, P. G., and Weber, J. "Gravity Experiments" from: Modern Science and Technology. D. Van Nostrand Co., Princeton, N.J., 1965.

III. Mechanics (Cont.)

15. UNIVERSAL GRAVITATION AND THE SOLAR SYSTEM (7 days)	INSTRUCTIONAL RESOURCES
<u>Motion in the heavens.</u> -The Greeks and astronomy. -Motions of the moon. -Heliocentric system of the solar system. -A geo-centric system and Ptolemy. <u>The works of Copernicus and Tycho Brahe.</u> -The Copernican system. -Arguments for the Copernican system. -Arguments against the Copernican system. -Historic consequences. -Tycho Brahe and his observations. -Tycho's compromise system. <u>The appearance of a new universe.</u> -Abandonment of uniform circular motion. -Kepler's second law. -Using Kepler's first two laws. -Kepler's third law. -Galileo's viewpoint and telescopic evidence. -Galileo's arguments. <u>The unity of earth and sky.</u> -Newton's Principia. -Newton's analysis; motion and a central force. -The inverse square law of planetary force. -Law of Universal Gravitation. -Gravitation and planetary motion.	TEXTS Basic: CPPSSC, Ch. 21 Supplementary: MCP, Ch. 9 Ch. 10 LABORATORY CPLG: Exp. 30 VISUAL AIDS Films: Universal Gravitation, PSSC (28) Elliptic Orbits, PSSC (18) OUTSIDE READING Toulmin, Stephen and Goodfield, June. "Copernicus, His Aim and His Theory" from: <u>The Fabric of the Heavens</u>. Harper and Row, N.Y., 1961, Ch. 6. Feynman, R.P., Leighton, R. B. and Sands, M. "Universal Gravitation" from: <u>The Feynman Lectures on Physics, Vol. 1</u>. Addison-Wesley, Reading, Mass. 1963, Ch. 7. Galileo: "The Starry Messenger" from: <u>Discoveries and Opinion of Galileo by Stillman Drake</u>. Doubleday and Co., Inc., 1957.

III. Mechanics (Cont.)

16. MOMENTUM AND THE CONSERVATION OF MOMENTUM (9 days)

INSTRUCTIONAL RESOURCES

Dynamics of motion.

- Impulse.
- Impulse as a vector.
- Momentum.
- The components of momentum.
- Momentum as a vector.
- Force and changes in momentum.

Changes in momentum through interaction of bodies.

- Explosions.
- Head-on collisions.
- Elastic and inelastic collisions.
- Glancing collisions.
- Law of conservation of momentum.
- Center of mass-quantity defined.

Action-reaction forces.

- Isolating a body.
- Rocket flights into space.
- Forces in a system before launch.
- Vertical and inclined flight.
- Free flight.

TEXTS

Basic: CPPSSC, Ch. 16

Supplementary: MCP, Ch. 5
Ch. 13
Ch. 16
Ch. 17

LABORATORY

CPLG: Exp. 31
Exp. 32
Exp. 33

VISUAL AIDS

Film:
Law of Conservation of Momentum, Coronet (18)

OUTSIDE READING

Bondi, Hermann. Relativity and
Common Sense. "Science Study
Series." Doubleday Anchor,
Chs. 1-4.

Holton, G. and Roller, D.H.D.
Foundations of Modern Physics
Science. Addison-Wesley, 1958,
Ch. 17.

III. Mechanics (Cont.)

17. WORK AND ENERGY (7 days)	INSTRUCTIONAL RESOURCES
<u>Work defined in physical terms.</u> -Energy transfer. -Energy transfer and work performed. -Fuel consumption. -Work and force. -Work and direction of applied force. <u>Kinetic energy.</u> -Energy in motion. -The dynamical characteristics of kinetic energy. <u>Interaction of bodies.</u> -Transfer of kinetic energy. -Simple collisions and K.E. -Elastic collisions and the conservation of K.E. -K.E. and momentum. -Work and K.E., more than one force. -Conservation of K.E. and inelastic collisions.	TEXTS Basic: CPPSSC, Ch. 17. Supplementary: MCP, Ch. 15 Ch. 16 LABORATORY CPLC: Exp. 34 VISUAL AIDS Films: Elastic Collisions and Stored Energy, PSSC (25) Momentum, Energy, and Center of Mass, PSSC (25) OUTSIDE READING Carnot, Sadi. "The Motive Power of Fire," an excerpt from the paper "Reflections on the Motive Power of Fire, and On Machines Fitted to Develop that Power" from: <u>Reflections on the Motive Power of Fire.</u> Dover Pub., N.Y., 1960. Forbes, R.J. and Dijksterhuis, E.J. "The Steam Engine Comes of Age" from: <u>A History of Science and Technology</u>, Vol. 2. Penguin Books, Ltd., Harmondsworth, Middlesex, England, 1963, Ch. 20. Thomson, William and Tait, P.G. "Energy" from: <u>Good Words for 1862</u>, Norman Macleod, Alexander Strachan and Co., London.

III. Mechanics (Cont.)

18. POTENTIAL ENERGY (8 days)	INSTRUCTIONAL RESOURCES
<u>Potential energy and its use.</u> -The spring bumper. -Conservation of mechanical energy. -The elastic interaction of a mechanical spring. -P.E. of a spring. -Conservation of energy in a spring. <u>P.E. of two interacting bodies.</u> -Separation forces and total energy. -P.E. and distance of separation. -Stored P.E. in a force field. <u>Gravitational force field.</u> -Gravitational P.E. near the surface of the earth. -Gravitational P.E. in general. -Escape energy, escape velocity, and binding energy of satellites. <u>Mechanical energy and a complex system; conservation of mechanical energy.</u>	TEXTS Basic: CPPSSC, Ch. 18 MCP, Ch. 25 LABORATORY CPLG: Exp. 35 Exp. 36 Exp. 37 VISUAL AIDS Film: Energy and Work, PSSC (28) Fs 530 Energy, Today and Tomorrow (38F) Fs 530 Energy (41D) OUTSIDE READING Feynman, R.P., Leighton, R.B. and Sands, M. "The Conservation of Energy" from: <u>The Feynman Lectures on Physics, Vol. I.</u> Addison-Wesley, Reading, Mass. 1963. Gamow, George. "Gravity," <u>Science Study Series.</u> Doubleday Anchor, 1962.

III. Mechanics (Cont.)

19. ANGULAR MOMENTUM AND ITS CONSERVATION (9 days)	INSTRUCTIONAL RESOURCES
<u>Angular momentum.</u> -Law of equal areas. -Frame of reference and angular momentum. -Energy, angular momentum, and trajectory. <u>The motion of satellites.</u> -Total energy and angular momentum. -The vector nature of angular momentum. <u>Rigid bodies.</u> -Rotation of rigid bodies. -Angular momentum of rigid bodies. -Moment of inertia. -Torque rate of change of angular momentum. -Orbital angular momentum and spin.	TEXTS Basic: CPPSSC, Ch. 19 Supplementary: MCP, Ch. 17 Ch. 19 Ch. 20 Ch. 21 LABORATORY CPLG: Exp. 38 Exp. 39 Exp. 40 ECP, Ch. 12, Section 12.2 VISUAL AIDS Film: Angular Momentum--A Quantity, PSSC (26) OUTSIDE READING Shonle, John I. "Resource Letter CM-1 on the Teaching of Angular Momentum and Rigid Body Motion," <u>American Journal of Physics</u>, Vol. 33, No. 11, Nov., 1965. Newton, Isaac. "Proposition I-The Law of Areas" from: <u>Book I of Mathematical Principles of Natural Philosophy and his System of the World</u>, Translated by Florian Cajori, University of Calif. Press, 1934.

III. Mechanics (Cont.)

20. HEAT, MOLECULAR MOTION AND CONSERVATION OF ENERGY (5 days)

INSTRUCTIONAL RESOURCES

Motions of small invisible particles.

-Gas pressure, Boltzmann's Constant,
and molecules.

-Temperature and molecular K.E.

-Internal energy.

Mechanical energy of bulk motion and internal energy.

-Quantitative study of the conservation
of mechanical to internal energy.

-Heat flow.

Quantitative relation of energy dissipation and temperature rise.

-Conservation of energy.

TEXTS

Basic: CPPSSC, Ch. 20

Supplementary: MCP Ch. 30

LABORATORY

CPLG: Exp. 41

ECP, Ch. 16 Sec. 16.1
Ch. 20 Sec. 20.1
20.2

VISUAL AIDS

Film:

Conservation of Energy PSSC
(27)

Fs 539 Kinetic-Molecular Theory
(59F)

OUTSIDE READING

Rogers, Eric M. "The Great
Molecular Theory of Gases"
from: Physics for the
Inquiring Mind. Princeton
Univ. Press, 1960.

Maxwell, Clark J. "On the
Kinetic Theory of Gases"
from: Theory of Heat.
Longmann, Green, and Co.,
London, 1872, Ch. 22.

III. Mechanics (Cont.)

21. IRREVERSIBLE PROCESS (4 days)	INSTRUCTIONAL RESOURCES
<u>Irreversible processes, examples of.</u>	TEXTS
<u>An experiment with marbles.</u>	Basic: CPPSSC, Ch. 21.
-Qualitative explanation of the marble experiment.	LABORATORY
-Basic ideas about probability.	CPLG: Exp 42
-States and distribution.	VISUAL AIDS
<u>Expansion of a gas.</u>	Film: Random Events, PSSC (17)
-Free expansion of a gas.	OUTSIDE READING
-Quantitative aspects.	Feynman, Leighton and Sands, M. <u>The Feynman Lectures on Physics.</u> Addison-Wesley Pub. Co. Inc., Reading, Mass. 1963, Vol. I, Ch. 6.
-Density fluctuations.	
-Inelastic collisions and heat conduction.	

III. Mechanics (Cont.)

22. ENTROPY (3 days)

INSTRUCTIONAL RESOURCES

Description of a physical system.

- The macroscopic state.
- Reversible process.
- The microscopic state.
- The gas oscillator.
- Adiabatic and isothermal processes.

Free expansion and isothermal expansion of an ideal gas.

Entropy

- Heat bath.
- Entropy changes in an inelastic collision.
- Entropy changes in heat conduction at constant volume.
- The entropy of an ideal gas when both volume and temperature change.
- Diffusion--the entropy of a perfect gas.

The Second Law of Thermodynamics.

TEXTS

- Basic: CPPSSC Ch. 22
Supplementary: MCP, Ch. 25

LABORATORY

None.

VISUAL AIDS

Film:
Mechanical and Thermal Energy
PSSC (22)

OUTSIDE READING

MacDonald, D.K.C. Near Zero.
Doubleday Anchor, Science
Study Series, 1961.

IV. Electricity and Atomic Structure

23. SOME QUANTITATIVE FACTS ABOUT ELECTRICITY (5 days)	INSTRUCTIONAL RESOURCES
<u>Electrostatic charges.</u> -Method of producing. -Forces between charged bodies. -Electrostatic forces and atomic charged particles. -Kinds of charges. -Charges in motion. -Conductors and insulators. <u>The electroscope</u> -Detection of charge. -Electrostatic induction. <u>Transfer of charge.</u> -Batteries. -Electric currents. -Conduction of gases--ionization. -Cloud chamber. -Conductivity of solutions. -Electrons in metals. -Diodes, electron guns, cathode-ray oscilloscopes.	TEXTS Basic: CPPSSC, Ch. 23 Supplementary: MCP, Ch. 47 LABORATORY CPLG: Exp. 43 Exp. 44 VISUAL AIDS Demonstration in electrostatics (nature of demonstrations dependent upon equipment available) Films: Electroscope, EBF (11) Electrostatics (11) OUTSIDE READING Ingalls, Albert G. "About Historic and Modern Machines for the Generation of Static Electricity" from: <u>The Amateur Scientist</u>. Scienti- fic American Inc., 1955. Weisskopf, Victor, F. <u>Knowledge and Wonder</u>. Doubleday Anchor Science Study Series, 1963.

IV. Electricity and Atomic Structure (Cont.)

24. COULOMB'S LAW AND THE ELEMENTARY ELECTRIC CHARGE (5 days)

INSTRUCTIONAL RESOURCES

Electrostatic force.

- Force and distance.

Force and charge.

- Electric force fields.
- Electric forces as vectors.
- Electric field patterns.
- Uniform force fields.

The Millikan experiment.

- Measuring small electrical forces.
- The fundamental natural unit of electric charge.
- Large electrical balance.
- Parallel plates and the electric field.
- Force between elementary charges.

Coulomb's Law and the constant of proportionality.

- Conservation of charge.
- The charge of an electron.

TEXTS

Basic: CPPSSC, Ch. 24

Supplementary: MCP, Ch. 50
Ch. 57

LABORATORY

CPLG: Exp. 45
Exp. 46

Millikan Oil Drop (Cenco)

VISUAL AIDS

Films:

Coulomb's Law, PSSC (24)

The Millikan Experiment,
PSSC (70)

Coulomb's Force Constant,
PSSC (34)

Electric Lines of Force,
PSSC (7)

Discovery of the Electron,
EBF (30)

Electronic Charge and Mass,
EBF (30)

OUTSIDE READING

Cavendish, Henry. "Experimental Determination of the Law of Electric Force" from: The Electrical Researches of the Honourable Henry Cavendish, F.R.S. Cambridge Univ. Press, Cambridge, England, 1879.

Magie, William Francis. A Source Book in Physics. McGraw Hill, 1935, pp. 408-20.

IV. Electricity and Atomic Structure (Cont.)

25. ENERGY AND MOTION OF CHARGES IN ELECTRIC FIELDS (3 days)	INSTRUCTIONAL RESOURCES
<u>Kinetic energy of a charged particle.</u> -Work and K.E. -The speed of a charged particle. -Measuring the speed of a charged particle. -Mass of the electron and proton. -The hydrogen atom. <u>Elementary charges in motion.</u> -Electric current. -Electric current and number of charges. -Constancy of current in a closed circuit. -Current and electrolysis. <u>EMF.</u> -EMF of a battery. -EMF and energy. -EMF defined. -Batteries in series. -Total energy of a battery. <u>Interaction between elementary charged particles.</u> -Electric field. -Electric potential. -Potential difference. -Components of potential difference. <u>Practical units of electricity.</u> -Volt, coulomb and ampere. -Electrical energy--electron volt. -Electrical power.	TEXTS Basic: CPPSSC, Ch. 25 Supplementary: MCP, Ch. 48 LABORATORY CPLG: Exp. 47 Exp. 48 ECP, Ch. 35, Sect. 35.1 VISUAL AIDS Films: Counting Electrical Charges in Motion, PSSC (23) Elementary Charges and Transfer of K.E., PSSC (33.5') E.M.F., PSSC (20) Fs 537.2 Current Electricity Part I (24F) Part II (27F) Part III (26F) OUTSIDE READING MacDonald, D.K.C. <u>Near Zero</u>, "Science Study Series." Doubleday Anchor, 1961, Ch. 3. MacDonald, D.K.C. "The Relativity of Electricity and Magnetism" from: <u>Faraday, Maxwell, and Kelvin</u>. Doubleday Anchor Inc. 1964.

IV. Electricity and Atomic Structure (Cont.)

26. THE RUTHERFORD ATOM (3 days)

INSTRUCTIONAL RESOURCES

The Rutherford atom.

- Deflection of alpha particles.
- Trajectories of alpha particles in the electric field of a nucleus.
- Angular distribution of scattering.

TEXTS

Basic: CPPSSC, Ch. 26

Supplementary: MCP, Ch. 60

LABORATORY

Mechanical Particle Scattering, revolving equipment (district)

Alpha Particle Scattering; use only weak sources.

VISUAL AIDS

Films:

Rutherford Atom, PSSC (40)
Atomic Theory, UW (09)
Bohr Atom, EBF (30)

Fs 539.76 Structure of the Atom (49F)

OUTSIDE READING

Romer, Alfred. The Restless Atom, Science Study Series. Doubleday Anchor, 1960, Ch. 13.

Born, Max. The Restless Universe. Dover, 1951, Ch. 4.

Andrade, E.M. Rutherford and the Nature of the Atom, Science Study Series. Doubleday Anchor, 1964.

IV. Electricity and Atomic Structure (Cont.)

27. ELECTRIC CIRCUITS (3 days)	INSTRUCTIONAL RESOURCES
<u>Electric field, potential and circuits.</u> -Potential difference and current flow. -Electric field and current flow. -Conductors and potential. <u>Measuring potential difference.</u> -Electrometers. -Voltmeters. -Current flow and measurement. <u>Elements of an electrical circuit.</u> -Definition of a circuit. -Conservation of energy in a circuit. -IR drops in a circuit. -Series and parallel resistors. -Kirchoff's Laws..	TEXTS Basic: CPPSSC, Ch. 27 Supplementary: MCP, Ch. 49 Ch. 50 LABORATORY CPLG: Exp. 49 VISUAL AIDS Films: Electric Potential Energy and Potential Difference, Parts I and II, PSSC (54) Principles of Electricity, GE (20) Series and Parallel Circuits, EBF, (10) Fs 537 Elements of Electrical Circuits (86F) Fs 537 Series and Parallel Circuits (86F) OUTSIDE READING Fink, Donald G. and Lutyens, David M. <u>The Physics of Television</u>, Science Study Series. Doubleday Anchor, 1960.

IV. Electricity and Atomic Structure (Cont.)

28. THE MAGNETIC FIELD (4 days)

INSTRUCTIONAL RESOURCES

The magnetic field.

- Detection and direction of a magnetic field, using a magnetic needle.
- Magnets and magnetic field.
- Electric currents and magnetic field.
- Hans Christian Oersted.

Nature of a magnetic field.

- Magnetic field strength.
- Magnitude of field and current flow.
- Vector nature of magnetic field.

Force and the magnetic field.

- The right-hand rule.
- The practical unit of the magnetic field.
- Force, current, and field.
- Meters and motors.

Current flow in a magnetic field.

- Force of a magnetic field.
- Magnetic field near a long straight wire.
- Uniform magnetic field.
- The mass of a charged particle and the magnetic field.
- Momentum of an alpha particle and the magnetic field.

TEXTS

Basic: CPPSSC, Ch. 28

Supplementary: MCP, Ch. 51

LABORATORY

CPLG: Exp. 50

Exp. 51

Exp. 52

ECP, Ch. 23, Sec. 23.1

VISUAL AIDS

Films:

A Magnet Laboratory, PSSC (20)

Electrons in a Uniform Magnetic Field, PSSC (10)

Mass of the Electron, PSSC (18)

Magnetic Force, McGH (29)

OUTSIDE READING

MacDonald, D.K.C. "The Relationship of Electricity and Magnetism" from: Farady, Maxwell, and Kelvin, Science Study Series. Doubleday and Co., 1964.

Maxwell, James Clark "On the Induction of Electric Currents" from: A Treatise on Electricity and Magnetism, Vol. 2. Clarendon Press, Oxford, 1881, Ch. 3.

IV. Electricity and Atomic Structure (Cont.)

29. ELECTROMAGNETIC INDUCTION AND ELECTROMAGNETIC WAVES (4 days)	INSTRUCTIONAL RESOURCES
<u>Michael Faraday</u> -Induced currents in a wire loop. -Induced current and velocity of a conductor. -Relative velocity between loop and magnetic field. <u>Magnetic flux.</u> -Definition of "magnetic flux." -Changing magnetic flux and its effects. -Methods of producing an induced current. <u>Changes in magnetic flux.</u> -Induced EMF. -Direction of the induced EMF. -Len's Law and conservation of energy. <u>Electromagnetic waves.</u> -Electric fields around changing magnetic fluxes. -Magnetic field around changing electric fields. -Mechanism of electromagnetic radiation. -The electromagnetic spectrum. -Electromagnetic character of light waves.	TEXTS Basic: CPPSSC, Ch. 29 Supplementary: MCP, Ch. 53 Ch. 54 Ch. 59 LABORATORY CPLG: Exp. 53 Exp. 54 Franck-Hertz Experiment Cenco. May be used as a demonstration-laboratory session. VISUAL AIDS Film: Electromagnetic Waves, PSSC (33) OUTSIDE READING Feynman, R.P., Leighton, R.B. and Sands, M. "Scientific Imagination" from: <u>Feynman Lectures on Physics, Vol. 2</u> Addison-Wesley, Reading, Mass. 1963, Ch. 20. Born, Max. "Electromagnetic Theory" from: <u>Einstein's Theory of Relativity.</u> Dover Publications Inc., N.Y. 1962, Ch. 5.

IV. Electricity and Atomic Structure (Cont)

30. SPECIAL THEORY OF RELATIVITY (4 days)

INSTRUCTIONAL RESOURCES

Relativistic kinematics.

- A medium for light waves.
- Waves in a moving media.
- One-way measurement of light.

Michelson-Morley Experiment; the Michelson interferometer.

The Lorentz contraction.

- Twin source interference in a moving medium.
- A first-order experiment with light.
- The speed of light--a universal constant.

The Fizeau experiment.

Relativistic addition of velocities.

Time and frame of reference.

- Lorentz transformation.
- Time dilation.
- An experiment with muons.
- Length of moving objects.
- The twin paradox.

TEXTS

Basic: CPPSSC, Ch. 30

Supplementary: MCP, Ch. 12
Ch. 46

LABORATORY

CPLG: Exp. 55
Exp. 56
Exp. 57
Exp. 58

VISUAL AIDS

Film:
Time Dilation, PSSC (15)

OUTSIDE READING

Bronowski, J. "The Arrow of Time" from: Insight. Harper and Row, N.Y., 1964.

Ciardi, John. "My Father's Watch" from: As If. Rutgers, The State University, 1956.

Feynman, Leighton, and Sands, M. The Feynman Lectures on Physics, Vol. 1. Addison-Wesley Pub. Co., Inc., Reading, Mass, 1963, Ch. 15.

IV. Electricity and Atomic Structure (Cont.)

31. PHOTOS (3 days)	INSTRUCTIONAL RESOURCES
<u>The graininess of light.</u> -X-rays -Photon model of light. <u>Properties of photons.</u> -The photoelectric effect. -Energy of photon and frequency. -Photoelectric current and light intensity. -Threshold wavelength. -Photon momentum. -Einstein's photoelectric equation. -The orderliness of chance. -Graininess and interference. <u>Reconciliation of particle and wave model of light.</u> -Electromagnetic waves and photons. -Planck's constant.	TEXTS Basic: CPPSSC, Ch. 31 Supplementary: MCP, Ch. 61 LABORATORY Project physics, Exp. 42 VISUAL AIDS Films: Photons, PSSC (18) Photoelectric Effect, PSSC (21) Pressure of Light, PSSC (21) OUTSIDE READING Born, Max. "Electromagnetic Theory" from: <u>Einstein's the Theory of Relativity.</u> Dover Pub. Inc., N.Y., 1962, Ch. 5.

IV. Electricity and Atomic Structure (Cont.)

32. SPEED, ENERGY AND MASS (3 days)	INSTRUCTIONAL RESOURCES
<u>Mechanical behavior of particle at high speed and large exchanges of energy.</u> -The ultimate speed. -Speed and K.E. -Momentum. -The momentum of photons, pressure of light. -Compton scattering. -Electron-positron annihilation. -Nuclear reactions and conservation of total energy. -Mass and energy. -Mass for photons.	TEXTS Basic: CPPSSC Ch. 32 Supplementary: MCP, Ch. 75 Ch. 76 LABORATORY None VISUAL AIDS Films: Ultimate Speed, PSSC, (23) Electron-Positron Annihilation, PSSC (19) Photon Collisions and Atomic Waves, EBF (30) OUTSIDE READING Bertozzi, W. "Things That Go Faster Than Light," <u>Scientific American</u>, July, 1960. Feynman, Leighton and Sands. <u>The Feynman Lectures on Physics</u>, Vol. 1. Addison-Wesley Pub. Inc., Reading, Mass. 1961, Ch. 16.

IV. Electricity and Atomic Structure (Cont.)

33. ATOMS AND SPECTRA (4 days)	INSTRUCTIONAL RESOURCES
<u>The stability of atoms.</u> -Frank-Hertz experiment; atomic energy levels. -Internal energy of the atom. <u>Atomic spectra.</u> -Excitation and emission. -Absorption spectra. -Energy loss and photon emission. -The hydrogen atom. -Energy levels of the hydrogen atom.	TEXTS Basic: CPPSSC, Ch. 33 Supplementary: MCP, Ch. 56 Ch. 58 Ch. 60 LABORATORY CPLG: Exp. 59 Exp. 60 VISUAL AIDS Films: The Frank-Hertz Experiment, PSSC (30) Light Sources and Their Spectra, EBF (30) Wavelength of Spectrum Lines, EBF (30) OUTSIDE READING Hoffman, Banesh. <u>Strange Story of the Quantum</u>, Dover Pub. 1959, Chs. 4, 5, and 8. Bitter, Francis. <u>Magnets--The Education of a Physicist</u>, Science Study Series. Double-day Anchor, 1959, Chs. 3 and 7.

IV. Electricity and Atomic Structure (Cont.)

34. MATTER WAVES (3 days)

INSTRUCTIONAL RESOURCES

Particle and wave model of light.

- de Broglie's hypothesis.
- Planck's constant.
- Interference and de Broglie's waves.
- Helium atoms and neutrons.

Light and matter.

- Conservation of energy and momentum.
- Newtonian approximations.
- Standing waves.
- A particle in a "box."

TEXTS

Basic: CPPSSC, Ch. 34

Supplementary: MCP, Ch. 62

VISUAL AIDS

Films:

Matter Waves, PSSC (28)

Interference of Photons
PSSC (13)

OUTSIDE READING

Hughes, Donald J. The Neutron
Story, Science Study Series.
Doubleday Anchor, 1960.

IV. Electricity and Atomic Structure (Cont.)

35. ATOMS, MOLECULES AND NUCLEI (4 days)	INSTRUCTIONAL RESOURCES
<u>Atomic structure.</u> -Hydrogen-like atoms--energy levels and size. -Helium ion and helium atom. -Lithium atom. <u>Electron binding.</u> -Absorption spectra. -Ionization energies. -Electron scattering. -Size of atoms. -Electron shells. <u>The Pauli principle; particles in a box.</u> <u>Chemical binding.</u> <u>The deuteron.</u> -The nuclear force. -Complex nuclei.	TEXTS Basic: CPPSSC, Ch. 35 Supplementary: MCP, Ch. 66 Ch. 77 LABORATORY None VISUAL AIDS Films: Interference of Photons, PSSC (26) Matter Waves, PSSC (17) Fs 539.14 Composition of Atoms (49F) Fs 539.7 What's in the Atom (41F) Fs 539.76 Structure of the Atom (49F) OUTSIDE READING Hecht, Selig. <u>Explaining the Atom</u>, rev. ed. Viking Press. Semat, Henry and Rapport, Samuel. <u>Atomic Age Physics</u>. Holt, Rinehart, and Winston. Chs. 6, 10.

IV. Electricity and Atomic Structure (Cont.)

36. CHANGE IN ATOMS AND NUCLEI (4 days)

INSTRUCTIONAL RESOURCES

Atomic and nuclear systems.

- Conservation of energy.
- Conservation of momentum and of angular momentum.
- Conservation of parity.
- Conservation of nucleons.

Atomic reactions.

- Atomic fission.
- Alpha decay.
- Lifetimes and barrier penetration.
- Alpha decay and barrier penetration.
- Lifetime and energy spread.
- Photon emission.

TEXTS

Basic: CPPSSC Ch. 36

Supplementary: MCP Ch. 78
Ch. 79
Ch. 80

VISUAL AIDS

Films:

Barrier Penetration--
Ripple Tank Wave Phenomenon
III, PSSC (26)

Inside the Nucleus and
Fission, EBF (30)

Nuclear Energy, EBF (30)

Atomic Energy, An Intro-
duction, EBF (11)

Nuclear Reactor, MCGH (09)

OUTSIDE READING

Einstein, Albert and Infeld,
Leopold. The Evolution of
Physics, The Growth of
Ideas from Early Concepts
to Relativity and Quanta.
Simon and Schuster, N.Y.

Faro, U. and Faro, L. Basic
Physics of Atoms and
Molecules. Wiley and Sons.

APPENDICES

APPENDIX A

Suggested Topics for Individual Study

MEASUREMENT

The history of the metric system

Present and future need for scientific personnel

The origin of the units of the English system

Contributions of atomic energy to medicine, industry, and so forth

The use of dimensional analysis in physics

Contributions of electronics to transportation

Precise measurements in industry

Research in industry

Development of vernier scales

The ammonia clock

The work of the United States Bureau of Standards

The work of the Naval Observatory

Government research agencies, Office of Naval Research, and so forth

The standard meter measure in terms of wave length

Radio transmission of standard frequency and time signals

The history of the calendar

MECHANICS

Perpetual motion machines

The Brachistochrone

Stresses in simple cranes and
trussels

Forces acting on a sailboat

Streamlining in transportation

Friction measuring devices

Standards for non-slip surfaces

The forces on a moving automobile

Space stations

Space ships

The ultracentrifuge and its
applications

Big Bertha

Rocket and missile design

Streamlining in transportation

Friction measuring devices

Standards for non-slip surfaces

The forces on a moving automobile

The Foucault pendulum

Theory of the gyroscope

The gyrocompass

The ship-stabilizing gyro

Elementary mechanics of billiards

Kepler's laws of planetary motion

The elastic properties of materials

Measurement of surface tension with
tensiometer

Canal lock systems

Measurement of surface tension
through capillary rise

Measurement of tensile and com-
pressive strength

The action of "wetting agents"

Uses of principle hydraulic press

Capillarity in soils

The Bathysphere

The hydraulic ram

Water systems

Uses of the Bernoulli principle

High altitude flights

Uses of pneumatics

HEAT

The historical development of the kinetic theory of gases

The development of the temperature scales

High and low temperature measuring instruments

Thermal expansions in structures

Thermostatic controls

The human calorimeter

The bomb calorimeter

Modern fuels

Solar heating, furnaces, and so forth

Thermal conductivity measurements

Meteorological instruments and data

Air conditioning

Modern gasoline and diesel engines

The gas refrigerator

Modern gas turbine

Early heat engines

WAVE MOTION AND SOUND

The physical pendulum

The history of the development of the musical scales

The history of the development of a musical instrument

Electronic musical instruments

Hearing tests and audiometry

The measurement of noise level

Velocity of sound measurements

Sonar

The production and application of ultrasonics

Architectural acoustics

Sound recording, hi-fidelity

LIGHT

Historical theories of light

The Michelson Morley experiment

The historical development of the method for determining the velocity of light

Applications of polarized light

Illumination requirements for home and industry

Stroboscopic effects and their uses

Color photography - still and motion pictures

The Palomar telescope

The deposition of films on glass

The pinhole camera

Optical illusions and mirages

Famous solar eclipses

Use of the spectrograph in industry

Light meters and their uses

Cameras and projectors

Lasers

ELECTRICITY AND MAGNETISM

Electrostatic generators

The electorstatic smoke eliminator

Lightning protection systems

The zerographic duplicating process

Theories of terrestrial magnetism

Corrections to the magnetic compass

The degaussing and deperring of ships

Electroplating

Electrolytic refining of metals

Electrode potentials

Special primary cells and their uses

Storage batteries

The location of faults in telephone lines

The development of the telephone

The electric power plant

Anti-gravity devices

The Oudin coil

The lives of Faraday, Tesla, Edison, Steinmetz, and so forth

The electro-magnetic pump

MODERN PHYSICS

The lives of the atomic scientists	Loran
The development of the periodic table	Piezo-electricity and its uses
The discovery of the various atomic particles	Long distance transmission of radio signals
The x-ray microscope	The allocation of radio frequencies
X-rays and their uses	The applications of radar to traffic control and enforcement
Radiation detectors and counters	The uses of the photronic cell
The use of radio-active isotopes as tracers	The methods of separation of uranium
Prospecting for radio-active minerals	The Hanford project
The uses of phosphorescent and flourescent materials	The biological effects of cosmic rays
The uses of infra-red radiation	The trans-uranium elements
Uses of ultra-violet light	The military applications of atomic energy
Electronic instruments in medical practice	The peacetime uses of atomic energy
Guided missiles	Radiological effects of the atomic bomb
Transistors and their uses	The atomic submarines
The magnetron	
Micro-wave relay systems	

APPENDIX B

Books, Periodicals, and Equipment

<u>Author</u>	<u>Title</u>	<u>Publisher</u>
<u>TEXT BOOKS</u>		
<u>Basic:</u>		
PSSC	<u>College Physics</u> , First Edition.	D. C. Heath
PSSC	<u>College Physics Laboratory Guide</u> .	D. C. Heath
PSSC	<u>Guide for Advanced Topics</u> - 2nd edition.	D. C. Heath
<u>Supplementary</u>		
White	<u>Modern College Physics</u> - 4th/5th edition.	Van Nostrand
White and Manning	<u>Experimental College Physics</u>	McGraw Hill
<u>CLASSROOM REFERENCE LIBRARY</u>		
- - - - -	<u>Science Study Series</u> (Paperbacks)	Doubleday
Brown, Thomas	<u>Foundations of Modern Physics</u>	John Wiley & Sons
Chemical Rubber Co.	<u>Handbook of Chemistry and Physics</u>	Chemical Rubber Co.
Ciofarri, Bernard	<u>Experiments in College Physics</u> , 2nd ed.	D. C. Heath
Glasstone, S.	<u>Source Book on Atomic Energy</u> , 2nd ed.	Van Nostrand
Knauss, Harold P.	<u>Discovering Physics</u>	Addison-Wesley
Ference, et al	<u>Analytical Experimental Physics</u> , 3rd ed.	Univ. of Chicago Press
Sears and Zemansky	<u>University Physics</u> , 2nd ed.	Addison-Wesley
Schaum, Daniel	<u>Outline of Theory and Problems for Students of College Physics</u>	Schaum Publishing Co.
Slater	<u>Modern Physics</u>	McGraw-Hill
Walter, M. J.	<u>Discovering Physics by Experiment</u>	Addison-Wesley

TEACHER REFERENCES:

Sutton, Richard	<u>Demonstration Experiments in Physics</u>	
Sears, Zemansky	<u>University Physics</u>	Addison-Wesley
Rogers, Eric	<u>Physics for the Inquiring Mind</u>	Princeton Press
Feynman,	<u>Lectures on Physics, Vols. I & II</u>	Addison-Wesley
Brown,	<u>L. W. Taylor Manual of Advanced Undergrad Exp. in Physics</u>	
Thomas	<u>Calculus and Analytical Geometry</u>	
Strong	<u>Procedures in Experimental Physics</u>	Prentiss Hall

PERIODICALS

<u>American Journal of Physics</u>	American Institute of Physics
<u>American Scientist</u>	Sigma Xi
<u>Physics Teacher</u>	
<u>Physics Today</u>	American Institute of Physics
<u>Science</u>	American Association for Advancement of Science
<u>Science Newsletter</u>	Science Service
<u>Science Teacher</u>	National Science Teacher Assoc.
<u>Scientific American</u>	Scientific American, Inc.

SCIENTIFIC AMERICAN ARTICLES RELATING TO PHYSICS

<u>1957</u>	<u>Title</u>	<u>Author</u>
January	New Methods of Radio Transmission Pions	Weisner Marshak
February	Atomic Clocks Inertia	Lyons Sciama
March	Fresh Water from Salt The Child and Modern Physics The Crab Nebula	Jenkins Piaget Oort
April	The Overthrow of Parity The Age of the Solar System Sun Clouds and Rain Clouds	Morrison Brown Roberts
May	The Shortest Radio Waves Diffusion in Metals	Gordy Cullity
June	A Rocket Around the Moon Radiation Pressure Atoms Visualized	Ehrlicke & Gamow Henry Müller
July	The Absorption of Radio Waves in Space Elementary Particles	Lilley Gell-Mann & Rosenbaum
August	The Origin of Hurricanes Electroluminescence How Fishes Swim The Ear The Plasma Jet	Malkus Ivey Gray Bekesy Giannini
October	Salt and Rain Plasmoids	Woodcock Bostick
November	Superconductivity	Matthias
December	Observations of Satellite I Fusion Power Heinrich Hertz	Whipple & Hynek Post Morrison

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1958</u>	<u>Title</u>	<u>Author</u>
January	Tracking Satellites by Radio Ultrahigh-Altitude Aerodynamics The Principle of Uncertainty	Meugel & Herget Schaaf Gamow
February	Strong Magnetic Fields Ancient Temperatures The Discovery of Fission	Furth Emiliani Hahn
March	Particle Accelerators Helmholtz	Wilson Crombie
April	Antimatter The Teaching of Elementary Physics	Burbidge & Hoyle Michels
May	Tornadoes A "Flying-Spot" Microscope The Earth As a Dynamo	Tepper Montgomery & Bonner Rosenbaum & Elsasser
June	Superfluidity Climate and the Changing Sun	Lifshitz Öpik
July	Prestressed Concrete More about Bat "Radar"	Lin Griffin
August	Hot Spots in the Atmosphere of the Sun Magnetic Resonance	Zirin Pake
September	Innovation in Physics Innovation in Technology The Encouragement of Science	Dyson Pierce Weaver
October	The Stellerator The Tails of Comets	Spitzer Biermann & Lüst
November	The Revival of Thermo Electricity Stellar Populations Drilling for Petroleum	Joffe Burbidge Marsden
December	Non-Military Nuclear Explosions The Maser	Johnson & Brown Gordon

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1959</u>	<u>Title</u>	<u>Author</u>
January	Dying Stars The Atomic Nucleus	Greenstein Peierls
February	Reactor Fuel Elements How Water Freezes	Schumar Chalmers
March	Radiation Belts Around the Earth The Weak Interactions Long Earthquake Waves	Van Allen Treiman Oliver
April	The Solar System Beyond Neptune Aligned Crystals in Metals	Gingerich Cullity
May	Nuclear Rockets Balloon Astronomy Experiments in Color Vision Artificial Satellites and Relativity	Newgard & Levoy Schwarzschild Land Giuzborg
June	Rocket Astronomy An Ancient Greek Computer Junction-Diode Amplifier	Friedman Price Uhlir
July	Pulsating Stars and Cosmic Distances The Exclusion Principle	Kraft Gamow
August	Satellites and the Earth's Atmosphere The Radio Galaxy Ocean Waves	Jastro Westerhout Bascom
September	Issue on Ionizing Radiation	
October	The Earth in the Sun's Atmosphere Fuel Cells	Chapman Austin
November	Ultrahigh Pressures The Invention of the Electric Light High Energy Cosmic Rays	Hall Josephson Rossi
December	The Arms of the Galaxy The Flow of Matter	Bok Reiner

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1960</u>	<u>Title</u>	<u>Author</u>
January	The 600-foot Radio Telescope Breeder Reactors The Green Flash	McClain Weinberg O'Connell
February	The Magnetism of the Sun Fracture in Solids Cosmic Spherules and Meteoritic Dust	Babcock Gilman Pettersson
March	Interplanetary Navigation Applications of Superconductivity The Nuclear Force	Mickelwait Bechhold Marshok
April	Life Outside the Solar System The Mossbauer Effect Radiation and the Human Cell	Huang Benedetti Puck
May	The Exploration of the Moon	Jastro
June	Solar Particles and Cosmic Rays Ferrites Humphry Davy	Anderson Hogan Williams
July	The Force Between Molecules The Zodiacal Light Metal Whiskers Things That Go Faster Than Light	Derjaguin Blackwell Brenner Rothman
August	Vertical-takeoff Aircraft Radar Astronomy The Structure of Liquids	Campbell Eshleman & Peterson Bernal
September	The Scientific Revolution	Butterfield
October	Optical Pumping High Speed Impact The Physics of Woodwinds Count Rumford	Bloom Charters Benade Wilson
November	Fiber Optics Superfluidity and "Quasi-Particles" The Age of the Solar System	Kapany Reif Reynolds
December	Nonuniform Magnetic Fields	Pohl

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1961</u>	<u>Title</u>	<u>Author</u>
January	Re-entry from Space Glass A New Scale of Stellar Distances The Growth of Snow Crystals	Becker Greene Wilson Mason
February	Peculiar Galaxies The Celestial Palace of Tycho Brahe	Burbidge Christenson
March	Electrical Propulsion in Space Gravity Lee Waves in the Atmosphere Monomolecular Films	Giannini Gamow Scorer Ries
April	The Size of the Solar System Ultrahigh-speed Rotation	McGuire Beams
May	The Temperature of the Planets From Faraday to the Dynamo	Mayer Sharlin
June	Optical Masers Subdwarf Stars The Airborne Magnetometer	Schawlow Burbidge Jensen
July	The Moon Weather Satellites Superconducting Computers	Perman Neiburger & Wexler Ittner & Kraus
August	Astroblemes The Reproduction of Sound Low-Altitude Jet Streams	Dietz David Barad
September	Issue on Cells	
October	Communication Satellites Observing Dislocation The Magnetism of the Ocean Floor	Pierce Dash & Tweet Raff
November	The Two-Mile Accelerator Tektites Maxwell's Color Photograph The Electrocardiogram	Ginzton & Kiuk Barnes Evans Schar
December	The Eötvös Experiment Galvanomagnetism and Thermomagnetism	Dicke Angrist

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1962</u>	<u>Title</u>	<u>Author</u>
January	Sonic Boom Aftereffects in Perception Hypernuclei Two-Phase Materials	Wilson Prentice Telegdi Slayter
February	The Solar Chromosphere Physiological Effects of Acceleration Wear	Athay Rogers Rabinowicz
March	Radio Galaxies Ultrahigh Vacuum The Longest Electromagnetic Waves	Heeschen Steinhertz & Redhead Heirtzler
April	Exploding Stars Paradox The Action of Adhesives The Soaring Flight of Birds	Kraft Quine de Bruyne Cone
May	Gamma Ray Astronomy Experiments with Goggles Exploding Wires	Kraushaar & Clark Kohler Bennett
June	The Detection of Underground Explosions Superconducting Magnets Computer Programs for Translation	Leet Kunzler & Tanenbaum Yngre
July	The Moon Illusion Telephone Switching	Kaufman & Rock Feder & Spencer
August	The Spark Chamber Neutrino Astronomy	O'Neill Morrison
September	The Antarctic and the Upper Atmosphere The Antarctic and the Weather	Wright Rubin
October	Ancient Fluids in Crystals Semiconductor Particle-Detectors	Roedder Bilaniuk
November	The Pleiades The Physics of Violins Neutron Radiograph	Limber Hutchins Berger
December	Desalting Water by Freezing Atmospheric Tides The Conduction of Heat in Solids Ultraviolet Radiation and Nucleic Acid	Snyder Butler Sproull Deering

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1963</u>	<u>Title</u>	<u>Author</u>
January	Resonance Particles The Evolution of Galaxies Why Do Roads Corrugate?	Hill Arp Mather
February	Rotation of Stars Shock Waves and High Temperature The Clock Paradox	Abt McChesney Bronowski
March	Organic Matter from Space Electric Location by Fishes The Two-Neutrino Experiment Ball Lightning	Mason Lissmann Lederman Lewis
April	Planetary Nebulae The Synthetic Elements	Liller Seaborg & Fritsch
May	The Physicist's Picture of Nature Moiré Patterns Radiation Belts	Dirac Oster & Nishijima O'Brien
June	The Ecological Effects of Radiation Noctilucent Clouds Kilomegacycle Ultrasonics Hydrogen in Galaxies	Woodwell Soberman Dransfeld Roberts
July	Advances in Optical Masers The Voyage of Mariner II The Fermi Surface of Metals	Schawlow James Mackintosh
August	Observatories in Space The Strength of Steel	Berman Zackay
September	Energy	Schurr
October	Conservation Laws Chondrites and Chondrules After Images	Feinberg & Goldhaber Wood Brindley
November	Plasmas in Solids Architectural Acoustics	Bowers Knudsen
December	Vehicular Traffic Flow Quasi-Stellar Radio Sources The Continuous Casting of Steel Magnetic Monopoles	Herman & Gardels Greenstein Gallagher & Old Ford

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1964</u>	<u>Title</u>	<u>Author</u>
January	The Large Cloud of Magellan Boron The Origins of the Steam Engine Advances in Field Emission	Bok Massey Ferguson Dyke
February	Tektites and Impact Fragments from the Moon Strongly Interacting Particles	OKeefe Chew
March	All Weather Aircraft Landing The Circulation of the Upper Atmosphere Fast-Neutron Spectroscopy The Discovery of Stellar Aberration	Brady Newell Cronberg Stewart
April	The Interaction of Light with Light The Solar Wind	Giordmaine Parker
May	High Voltage Transmission Dwarf Galaxies	Barthold & Pfeiffer Hodge
June	The Supersonic Transport X-ray Astronomy Magneto Thermoelectricity	Bisplinghoff Friedman Wolfe
July	Radiowaves from Jupiter	Franklin
August	Radio-emitting Flare Stars Liquid Crystals	Lovell Ferguson
September	Probability Mathematics in the Physical Sciences	Kac Dyson
October	The Omega-Minus Experiment Micrometeorology	Fowler & Samios Sutton
November	Exploding Galaxies The Solid State of Polyethylene The Michelson-Morley Experiment	Sandage Wunderlich Shankland
December	Hurricane Modification Three-Pigment Color Vision Fluid Control Devices	Simpson & Malkus MacNichol Angrist

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1965</u>	<u>Title</u>	<u>Author</u>
January	Infrared Astronomy by Balloon The Undercooling of Liquids Magnetic Resonance of High Pressure	Strong Turnbull Benedek
February	Superconductivity at Room Temperature Fiber-reinforced Metals The Age of the Orion Nebula	Little Kelly Vandervoort
March	The Structure of Crystal Surfaces The Magnetosphere De Forest and the Triode Detector Computer Experiments in Fluid Dynamics	Germer Cahill Chipman Harlow
April	Intense Magnetic Fields The Discovery of Icarus The Stirling Refrigeration Cycle	Kolm & Freeman Richardson Köhler
May	The Luminescence of the Moon High Pressure Technology Molecular Beams	Kopal Zeitlin Frisch
June	Photography by Laser The Magnetic Field of the Galaxy Corona Chemistry	Leith & Upatnieks Berge & Seielstad Coffman & Browne
July	Hydroxyl Radicals in Space Ultrastrong Magnetic Fields	Robinson Bitter
August	Infrared Astronomy Nuclear Fission Density Gradients	Murry & Westphal Leachman Oster
September	Issue on Urbanization	
October	Electrical Effects in Bone Chance Quantum Effects in Superconductors	Bassett Ayer Parks
November	Resonant Vibrations of the Earth Microelectrons	Press Hittinger & Sparks
December	Violations of Symmetry in Physics The Aurora The Physics of the Piano	Wigner Akasoju Blackham

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1966</u>	<u>Title</u>	<u>Author</u>
January	Communication by Laser Ranger Missions to the Moon	Miller Schurmeier
February	Neutrinos from the Atmosphere and Beyond Stress-corosion Failure	Reines Swann
March	The Voyage of Mariner IV	James
April	Chemical Lasers The Photographs from Mariner IV The Muonium Atom	Pimentel Leighton Hughes
May	The Scientific Experiments of Mariner IV	Sloan
June	Locating Radio Sources with the Moon Applications of the Coanda Effect	Clarke Reba
July	The Detection of Underground Explosions Polarized Accelerator Targets	Bullard Shapiro
August	A Solid-State Source of Microwaves The Origin of Cosmic Rays The Study of Sailing Yachts	Bowers Burbidge Herreshoff & Newman
September	The Uses of Computers in Technology The Uses of Computers in Science	Coons Oettinger
October	Night Blindness Science in History, by J. D. Bernal The Origins of the Copernican Revolution	Dowling Pirie Ravetz
November	Magnetic Fields on the Quiet Sun	Livingston
December	Noise The Problem of the Quasi-Stellar Objects Progress Toward Fusion Power	Beranek Burbidge & Hoyle Fowler & Post

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1967</u>	<u>Title</u>	<u>Author</u>
January	Can Time go Backward? Electric Currents in Organic Crystals	Gardner Pope
February	Reversals of the Earth's Magnetic Field The Solvated Electron	Cox, Dalrymple & Doell Dye
March	The Origin of the Automobile Engine The Surface of the Moon Advances in Superconducting Magnets	Bryant Hibbs Sampson, Craig & Strongin
April	Antimatter and Cosmology Neutron-Activation Analysis	Alfvén Wahl & Kramer
May	Ordinary Matter A Third-Generation of Breeder Reactors Light-Emitting Semiconductors Vision and Touch	Feinberg Bump Morehead Rock & Harris
June	Liquid Lasers	Lempicki & Samelson
July	The Leakage Problem in Fusion Reactors	Chen
August	The Youngest Stars	Herbig
September	The Electrical Properties of Materials The Magnetic Properties of Materials The Thermal Properties of Materials The Nature of Metals The Solid State	Ehrenreich Keffer Zinman Cottrell Mott
October	The Shape of the Earth Interstellar Grains	King-Hele Greenburg
November	Gravitational Collapse Maxwell's Demon	Thorne Ehrenberg
December	The Vibrating String of the Pythagoreans Scattering High-Energy X-Ray Stars Zone Refining	Helm Barger & Cline Giacconi Pfann

SCIENTIFIC AMERICAN ARTICLES (Cont.)

<u>1968</u>	<u>Title</u>	<u>Author</u>
January	Remote Sensing of Natural Resources The Circulation of the Sun's Atmosphere Perpetual Motion Machines	Colwell Starr et. al. Angust
February	The Arrival of Nuclear Power Advances in Holography	Hogerton Pennington
March	Channeling in Crystals Pulse Code Modulation	Bassedt Mayo
May	The Three Spectroscopics The Heat Pipe The Lunar Orbiter Mission to the Moon	Weisskopf Eastman Levin et. al.

LIBRARY REFERENCE MATERIALS--It is recommended that each school library should have a reference collection similar to the following list. The items marked with (*) are valuable teacher reference books.

<u>AUTHOR</u>	<u>TITLE</u>	<u>PUBLISHER</u>
Alter, D., et al	<u>Pictorial Astronomy</u>	Thomas Y. Crowell
Andrade, E. N.	<u>Sir Issac Newton</u>	Macmillan
Angelo, E., Jr.	<u>Electronic Circuits</u>	McGraw-Hill
Ashford, Theo. A.	<u>From Atoms to Stars</u>	Henry Holt Co.
Asimov, Isaac	<u>Building Blocks of the Universe</u>	Abelard Schuman Ltd.
Asimov, Isaac	<u>Only A Trillion: Speculations and Explorations on the Marvel of Science</u>	Abelard Schuman Ltd.
Asimov, Isaac	<u>The Chemicals of Life</u>	Abelard Schuman Ltd.
Barnett, Lincoln	<u>The Universe and Dr. Einstein</u>	Sloane
Behrens, Charles F.	<u>Atomic Medicine</u>	Nelson
Berkeley, E. C. and Wainwright, L.	<u>Computers: Their Operation and Applications</u>	Reinhold Pub.
Besancon, R. M.	<u>Encyclopedia of Physics</u>	Reinhold Pub.
Bishop, Amasa	<u>Project Sherwood</u>	Wesleyan Univ. Press
Bitter, Francis	<u>Magnets</u>	Wesleyan Univ. Press
Bohr, Niels	<u>Atomic Physics and Human Knowledge</u>	Wiley and Sons
Bonner, F. T. and Phillips, H.	<u>Principles of Physical Sciences</u>	Addison-Wesley
Boucher, Paul E.	<u>Fundamentals of Photography</u> (4th ed.)	Van Nostrand
Boys, C. V.	<u>Soap Bubbles</u>	Wesleyan Univ. Press
Bragg, Sir William	<u>Concerning the Nature of Things</u>	Dover
Burton, E. F. and Kohl, W. H.	<u>The Electron Microscope</u>	Reinhold

<u>AUTHOR</u>	<u>TITLE</u>	<u>PUBLISHER</u>
Carlin, B.	<u>Ultrasonics</u>	McGraw-Hill
Coggins, Jack	<u>Rockets, Jets, Guided Missiles and Space Ships</u>	Random House
*Coleman, James	<u>Relativity for the Layman</u>	Frederick Press
Cook, James G.	<u>Electrons Go to Work</u>	Dial
Cooper, M.	<u>Inventions of Leonardo da Vinci</u>	Macmillan
Courant, Richard and Robbins, Herbert	<u>What is Mathematics?</u>	Oxford U.P.
D'Abro, A.	<u>The Rise of the New Physics</u>	Dover
Dantzig, Tobias	<u>Number, The Language of Science</u>	Macmillan
Davis, Helen Miles	<u>Science Exhibits</u>	Science Service
*Davis, Helen Miles	<u>Scientific Instruments You Can Make</u>	Science Service
*Dean, Gordon	<u>Report on the Atom</u>	Alfred A. Knopf
*Eaton, James	<u>Beginning Electricity</u>	Macmillan
Eddington, A.	<u>Nature of the Physical World</u>	U. of Michigan
Editors of Scientific American	<u>Scientific American Reader</u>	Simon and Schuster
Einstein, Albert	<u>Out of my Later Years</u>	Philosophical Lib. (out of print)
*Einstein, Albert and Infeld, Leopold	<u>The Evolution of Physics: The Growth of Ideas from Early Concepts to Relativity and Quanta</u>	Simon and Schuster
Epstein, Beryl and Epstein, Samuel	<u>The Rocket Pioneers: On the Road to Space</u>	Messner, Julian
Evans	<u>Experiments in Electronics</u>	Prentice Hall
Faraday, M.	<u>On the Various Forces of Nature</u>	Crowell
Faro, U. and Faro, L.	<u>Basic Physics of Atoms & Molecules,</u> text ed.	Wiley

<u>AUTHOR</u>	<u>TITLE</u>	<u>PUBLISHER</u>
Faro, U.	<u>Basic Physics of Atoms and Molecules</u>	M. I. T.
*Fermi, Laura	<u>Atoms in the Family: My Life with Enrico Fermi</u>	Univ. of Chicago
Friend, J. Newton	<u>Numbers: Fun and Facts</u>	Scribner's
Gamow, George	<u>Biography of Physics</u>	Harper
Gamow, George	<u>The Birth and Death of the Sun</u>	Mentor Books
Gamow, George	<u>Matter, Earth, and Sky</u>	Prentiss Hall
Gamow, George	<u>Mr. Thompkins Explores the Atom</u>	Cambridge Univ.
Gamow, George	<u>Mr. Thompkins in Wonderland</u>	Cambridge Univ.
Gamow, George	<u>Mr. Thompkins Learns the Facts of Life</u>	Cambridge Univ.
Gamow, George	<u>One, Two, Three--Infinity</u>	Viking Press
Gamow, George and Stern, Marvin	<u>Puzzle-Math</u>	Viking Press
Garner, Louis	<u>Transistor Circuits</u>	Coyne
*Glasstone, Samuel	<u>Sourcebook on Atomic Energy (2nd ed.)</u>	Van Nostrand
Gray, Dwight E.	<u>Radiation Monitoring in Atomic</u>	Van Nostrand
Griffin, D. R.	<u>Echoes of Bats and Men</u>	Wesleyan Univ. Press
*Hannay, Norman B.	<u>Semiconductors</u>	Reinhold Pub.
*Hecht, Selig	<u>Explaining the Atom (rev. ed.)</u>	Viking Press
*Hogben, Lancelot	<u>Mathematics for the Million (3rd ed.)</u>	Norton, W. W.
Hogben, Lancelot	<u>Science for the Citizen</u>	Norton, W. W.
Holton, Gerald J. or	<u>Introduction to Concepts and Theories in Physical Science (1952)</u>	Addison-Wesley
Holton, Gerald J.	<u>Foundations of Modern Physical Science (1958)</u>	Addison-Wesley

<u>AUTHOR</u>	<u>TITLE</u>	<u>PUBLISHER</u>
Hornung, Julius L.	<u>Radar Primer</u>	McGraw Hill
Hoyle, Fred	<u>Frontiers of Astronomy</u>	Mentor
Hoyle, Fred	<u>The Nature of the Universe</u>	Mentor
Jammer, M.	<u>Concepts of Space</u>	Harvard Press
Jeans, J. H.	<u>The Growth of Physical Science</u>	Cambridge Univ. Press, London
*Jenkins, F. A. and White, H. E.	<u>Fundamentals of Optics, 3rd ed.</u>	McGraw-Hill
Jungk, Robert	<u>Brighter Than A Thousand Suns</u>	Harcourt Brace
Kahn, Fritz	<u>Design of the Universe</u>	Crown Publishers
Landau, L. D.	<u>What Is Relativity</u>	Basic Books
Lemon, H. B.	<u>From Galileo to the Nuclear Age</u>	Univ. of Chicago Press
*Ley, Willie	<u>The Conquest of Space</u>	Viking Press
*Ley, Willie and Von Braun, W.	<u>The Exploration of Mars</u>	Viking Press
*Ley, Willie	<u>Rockets, Missiles and Space Travel (rev. ed.)</u>	Viking Press
Ley, Willie	<u>Satellites, Rockets, and Outer Space</u>	New American Library
*Lieber, T. C.	<u>The Education of T. C. Mits</u>	Norton, W. W.
*Lieber, Lillian R.	<u>Einstein Theory of Relativity</u>	Holt, Rinehart & Winst
*Lieber, Lillian R.	<u>Infinity</u>	Holt, Rinehart & Winst
Luhr, O.	<u>Physics Tells Why</u>	Ronald
MacCurdy, E.	<u>Notebook of Leonardo da Vinci</u>	Braziller
McLaughlin, Howie	<u>Space Age Dictionary</u>	
Meyer, Jerome S.	<u>Fun with Mathematics</u>	World Publisher
Messel, H.	<u>Introduction to Modern Physics</u>	St. Martins

<u>AUTHOR</u>	<u>TITLE</u>	<u>PUBLISHER</u>
Minnaert, M.	<u>The Nature of Light and Color in Open Air</u>	Dover Press
Moore, Patrick	<u>The Story of Man and the Stars</u>	Norton, W. W.
Mott, M. F. and Jones, H.	<u>The Theory of the Properties of Metals and Alloys</u>	Dover Press
Park, David	<u>Contemporary Physics</u>	Harcourt
*Payne-Gaposchkin, Cecelia	<u>Stars in the Making</u>	Harvard Univ.
Peierls, R. E.	<u>The Laws of Nature</u>	Charles Scribner
Pfeiffer, John	<u>Changing Universe, The</u>	Random House
Pierce, J. R.	<u>Electrons, Waves and Messages</u>	Doubleday
Reid, Constance	<u>From Zero to Infinity</u>	Thomas Y. Crowell
Ridenour, L.	<u>Modern Physics for the Engineer</u>	McGraw
*Rogers, E.	<u>Physics for the Inquiring Mind</u>	Princeton Univ. Press
Roberts, John	<u>Heat and Thermodynamics, 5th ed.</u>	Interscience
Rossi, B.	<u>Cosmic Rays</u>	McGraw
Santillana	<u>Crime of Galileo</u>	Univ. of Chicago
Scott, W. T.	<u>The Physics of Electricity & Magnetism</u>	Wiley
*Sears, F. W.	<u>Mechanics, Wave Motion and Heat</u>	Addison-Wesley
*Sears, F. W. and Zemansky, M. W.	<u>University Physics</u>	Addison-Wesley
*Semat, Henry	<u>Introduction to Atomic and Nuclear Physics</u>	Holt, Rinehart & Winston
*Semat, Henry	<u>Physics in the Modern World</u>	Holt, Rinehart & Winston
*Semat, Henry and White, H.	<u>Atomic Age Physics</u>	Holt, Rinehart & Winston
Skilling, H. H.	<u>Exploring Electricity: Man's Unfinished Conquest</u>	Ronald Press

<u>AUTHOR</u>	<u>TITLE</u>	<u>PUBLISHER</u>
Sutton, R.	<u>Physics of Space</u>	Holt
Swezey, Kenneth M.	<u>Science Magic</u>	McGraw Hill
Von Laue, M.	<u>History of Physics</u>	Academic
Weizsacker	<u>Contemporary Physics</u>	Braziller
Wilson, E.	<u>An Introduction to Scientific Research</u>	McGraw Hill
Wilson, M.	<u>Energy</u>	Silver Burdett
*Woodbury, David O.	<u>The Glass Giant of Palomar</u>	Dodd, Mead & Co.
*Wright, Helen and Rapport, Samuel, eds.	<u>Great Adventures in Science</u>	Harper
Young, M. E.	<u>Radiological Physics</u>	Academic Press
	<u>Encyclopedia of Science and Technology</u>	McGraw Hill
	<u>Man, Rockets and Space</u>	Julian Messner
	<u>Mathematics of the Imagination</u>	Simon and Schuster
	<u>The Mighty Force of Research</u>	McGraw Hill
	<u>Yearbook of Science and Technology</u> <u>1962</u>	McGraw Hill
	<u>Yearbook of Science and Technology</u> <u>1963</u>	McGraw Hill
	<u>Yearbook of Science and Technology</u> <u>1964</u>	McGraw Hill

LIST OF PHYSICS EQUIPMENT TO BE SHARED BY SCHOOLS

The following equipment items have been provided on a circulatory basis among schools in each area.

<u>DESCRIPTION</u>	<u>AREA AND SCHOOL HOLDING CUSTODY</u>		
	<u>WEST</u>	<u>CENTRAL</u>	<u>EAST</u>
Alpha Ray Apparatus, Hoag, Welch 621A o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Alpha Ray Track Apparatus, Cenco 71245	Pt. Loma	Clairemont Hoover	Crawford Morse
Ballistic Pendulum, Blackwood Form	Pt. Loma	Clairemont Hoover Madison	Morse
Brenner Torque Demonstrator	I.A.D.C	I.A.D.C.	I.A.D.C
Canal Ray Tube, Wien, Cenco 71525	Mission Bay Pt. Loma	Hoover Madison	Morse
Choke & Resonance, Demonstration, Welch 2601B o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Diffusion Pump (High Vacuum)		Clairemont	
Electromagnetic demonstration set, Welch 2462 o/e	La Jolla Pt. Loma	Madison	Lincoln Morse
Inertial Masses, Cylindrical, Cenco 75305	Mission Bay	Kearny	Crawford
Interferometer, with Accessory Lamp, Michelson Cenco 71857, 71859-26	San Diego	Clairemont Madison	Crawford Morse
Mechanical Equivalent of heat apparatus, Welch 1684 o/e	La Jolla Pt. Loma	Madison	Lincoln Morse
Microwave Optics Equip., Cenco 80422, 80429-3 80429-4, 80434	Pt. Loma	Clairemont Hoover Madison	Morse
Nuclear Scattering Apparatus, Welch 615	Mission Bay	Kearny Madison	Lincoln Morse
Oil Drop Apparatus Kit, Welch 620 o/e	Pt. Loma	Clairemont Madison	Lincoln Morse

West: La Jolla, Mission Bay, Point Loma, San Diego
Central: Clairemont, Hoover, Kearny, Madison
East: Crawford, Henry, Lincoln, Morse

LIST OF PHYSICS EQUIPMENT (Cont.)

<u>DESCRIPTION</u>	<u>AREA AND SCHOOL HOLDING CUSTODY</u>		
	<u>WEST</u>	<u>CENTRAL</u>	<u>EAST</u>
Photoelectric Relay, demonstration, Welch 2148g o/e	La Jolla Pt. Loma	Madison	Lincoln Morse
Power Supply, demonstration, Welch 2138 o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Power Unit, high voltage, for Oil Drop Apparatus, Welch 620K o/e	Pt. Loma	Clairemont	Lincoln Morse
Radio Receiver, demonstration, Welch 2620 o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Radio Transmitter, demonstration, Welch 2621 o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Specific Charge of Electron Apparatus, Cenco 71264	Pt. Loma	Clairemont Madison	Lincoln Morse
Stroboscope, 480 to 60,000 vib/min., Welch 2154 o/e	Pt. Loma	Clairemont Kearny Hoover (2) Madison	Morse
Support, Rotating, ball bearing, Cenco 75265	Mission Bay	Kearny Madison	Crawford
Triode Demonstrator, Welch 2152 D	Pt. Loma	Clairemont Hoover	
Ultrasonics, demonstration, Cenco 71870	Mission Bay San Diego	Madison	Crawford Morse
Voltmeter, for Oil Drop Apparatus, Welch 3087 o/e	Pt. Loma	Clairemont Madison	Lincoln Morse
Wave Demonstrator, Bell Labs		Clairemont Kearny	Crawford

APPENDIX C

Supplementary Materials
for Reproduction

	CGS	THREE AS	
Electric flux density	esu emu	$1/(12\pi \times 10^9)$ $10^3/4\pi$	coulomb m ⁻²
Permittivity	esu	8.854×10^{-12}	farad m ⁻¹
Potential difference	statvolt (esu) abvolt (emu)	300 10^{-8}	volt
Capacitance	statfarad (esu) abfarad (emu)	$1/(9 \times 10^{11})$ 10^9	farad
Current	statamp (esu) abamp (emu)	$1/(3 \times 10^9)$ 10	amp
Magnetic flux density	gauss (emu) line in ⁻² esu	10^{-4} 1.550×10^{-4} 3×10^6	weber m ⁻²
Magnetic flux	maxwell (emu) esu	10^{-8} 3×10^2	weber
Resistivity	ohm cm ohm/mil ft	10^{-9} 1.662×10^{-9}	ohm m
Resistance	statohm (esu) abohm (emu)	9×10^{11} 10^{-9}	ohm
Magnetic field strength	amp turn cm ⁻¹ oersted (emu)	10^3 $10^3/4\pi$	amp turn m ⁻¹
Permeability	emu	$4\pi \times 10^{-7}$	henry m ⁻¹
Inductance	abhenry (emu) stathenry (esu)	10^{-9} 9×10^{11}	henry
Illuminance	lumen ft ⁻²	10.764	lumen m ⁻² (lux)
Luminance	lumen ft ⁻² steradian ⁻¹	10.764	lumen m ⁻² steradian ⁻¹

In 1935 the International Committee on Weights and Measures, the central authority on all questions of international scientific standards, legislated that the M. K. S. system of units be substituted for the C. G. S. system beginning January 1, 1940. Under this system the standards of mass and length are used as basic units. The principal feature of the M. K. S. system is that it legitimizes the practical units of electricity and removes the need for further use of the electrostatic and electromagnetic units.

THE MKS SYSTEM

THE UNITS

CONCEPT	ASA STANDARD LETTER SYMBOL	MKS UNIT
MECHANICS		
Distance	<i>s</i>	meter
Area	<i>A, S, σ</i>	m ²
Volume	<i>V</i>	m ³
Time	<i>t</i>	second
Velocity	<i>u, v</i>	m sec ⁻¹
Acceleration	<i>a</i>	m sec ⁻²
Angle	<i>θ</i>	radian
Solid angle	<i>ω</i>	steradian
Angular velocity	<i>ω</i>	radian sec ⁻¹
Angular acceleration	<i>α</i>	radian sec ⁻²
Mass	<i>m</i>	kilogram
Force	<i>F</i>	newton
Weight	<i>w, F, (W)</i>	newton
Torque		newton m
Moment of inertia	<i>I</i>	kg m ²
Momentum	<i>p</i>	kg m sec ⁻¹
Impulse		newton sec
Energy	<i>E</i>	joule
Power	<i>P</i>	watt
Pressure	<i>p</i>	newton m ⁻²
Density	<i>ρ, (D)</i>	kg m ⁻³
HEAT		
Quantity of heat	<i>Q</i>	joule
Specific heat capacity	<i>c</i>	joule kg ⁻¹ deg ⁻¹
Conductivity	<i>k</i>	watt m ⁻¹ deg ⁻¹
Diffusivity		m ² sec ⁻¹
Entropy	<i>S</i>	joule deg ⁻¹
ELECTRICITY AND MAGNETISM		
Charge	<i>q, Q</i>	coulomb
Electric field strength	<i>E</i>	volt m ⁻¹
Electric flux density	<i>D</i>	coulomb m ⁻²
Permittivity	<i>ε</i>	farad m ⁻¹
Potential difference	<i>V</i>	volt
Capacitance	<i>C</i>	farad
Current	<i>i, I</i>	ampere
Current density	<i>J</i>	amp m ⁻²
Electrochemical equivalent	<i>z</i>	kg coul ⁻¹
Magnetomotive force	<i>ℱ</i>	amp turn
Magnetic flux density	<i>B</i>	weber m ⁻²
Magnetic flux	<i>Φ</i>	weber
Magnetic pole strength	<i>p, (m)</i>	weber
Magnetic moment	<i>m</i>	weber m
Resistivity	<i>ρ</i>	ohm m
Resistance	<i>R, (r)</i>	ohm
Magnetic field strength	<i>H</i>	amp turn m ⁻¹
Permeability	<i>μ</i>	henry m ⁻¹
Inductance	<i>L</i>	henry

PHOTOMETRY

Illuminance	<i>E</i>	lumen m ⁻²
Luminance	<i>B</i>	lumen m ⁻² steradian ⁻¹
Luminous flux	<i>F</i>	lumen

Atomic Constants

(MKS Units, based on J. W. M. DuMond and E. Richard Cohen Report to National Research Council Committee on Constants and Conversion Factors of Physics, December, 1950).

F	Faraday	$(9.65194 \pm 0.00007) \times 10^7$ coul equiv ⁻¹ (physical scale)
N_0	Avogadro's number	$(6.02544 \pm 0.00011) \times 10^{23}$ (physical scale)
h	Planck's constant	$(6.62377 \pm 0.00018) \times 10^{-34}$ joule sec
m	Electron mass	$(9.10721 \pm 0.00025) \times 10^{-31}$ kgm
e	Electronic charge	$(1.601864 \pm 0.000024) \times 10^{-19}$ coul
e/m	Specific electronic charge	$(1.758897 \pm 0.000032) \times 10^{11}$ coul kgm ⁻¹
α	Fine structure constant	$(7.29698 \pm 0.00005) \times 10^{-3}$
$h/(mc)$	Compton wavelength	$(2.426067 \pm 0.000032) \times 10^{-12}$ m
a_0	First Bohr radius	$(0.529151 \pm 0.000003) \times 10^{-10}$ m
σ	Stefan-Boltzmann constant	$(5.6699 \pm 0.0009) \times 10^{-8}$ joule m ⁻² deg ⁻⁴ sec ⁻¹
$c_1 = 8\pi^2 hc$	First radiation constant	$(4.98071 \pm 0.00014) \times 10^{-24}$ joule m
$c_2 = hc/k$	Second radiation constant	$(1.438868 \pm 0.00006) \times 10^{-3}$ m deg
$\lambda_{max} T$	Wien displacement law constant	$(0.289757 \pm 0.000012) \times 10^{-2}$ m deg
μ_B	Bohr magneton	$(0.927120 \pm 0.000022) \times 10^{-23}$ amp m ²
$H^+/m_e V_0$	Ratio, proton mass to electron mass	1836.139 ± 0.034
mc^2	Energy equivalent of electron mass	(0.5109989 ± 0.000010) Mev
k	Boltzmann constant	$(1.38026 \pm 0.00006) \pm 10^{-23}$ joule deg ⁻¹
c	Velocity of light	$(2.997902 \pm 0.000009) \times 10^8$ m sec ⁻¹
R_∞	Rydberg constant for infinite mass	(10973732.3 ± 1.0) m ⁻¹
R	Universal gas constant	$(8.31665 \pm 0.00034) \times 10^3$ joule mol ⁻¹ deg ⁻¹
V_0	Standard volume of ideal gas	(22.4207 ± 0.0004) m ³ mol ⁻¹

Conversion Factors

A conversion factor is a dimensionless ratio used to make a change in units. Thus the conversion factor

12 in
1 ft

(read, "There are 12 inches in 1 foot") may be used to convert 10 feet to inches by direct multiplication and cancellation of the units, fact. To convert 15 inches to feet we evidently must invert the conversion factor to produce the desired result and multiply by

1 ft
12 in

(read, "In 1 foot there are 12 inches").

When the conversion factor is used incorrectly we notice immediately that the desired cancellation of units is not obtained and this is the signal to invert the factor.

To convert lb ft⁻² to kg m⁻² we proceed as follows:

$$\frac{\text{lb}}{\text{ft}^2} \times \frac{453.59 \text{ gm}}{1 \text{ lb}} \times \frac{1 \text{ kg}}{1000 \text{ gm}} \times \frac{(1 \text{ ft})^2}{(30.480 \text{ cm})^2} \times \frac{(100 \text{ cm})^2}{(1 \text{ m})^2} = 16.018 \text{ kg m}^{-2}.$$

The conversion factor is the

$$\frac{16.018 \text{ kg m}^{-2}}{1 \text{ lb ft}^{-2}}.$$

To convert mi to yd, proceed as follows:

$$1 \text{ mi} \times \frac{1609.4 \text{ m}}{1 \text{ mi}} \times \frac{1 \text{ yd}}{0.9144 \text{ m}} = 1760 \text{ yd}.$$

The conversion factor is:

$$\frac{1760 \text{ yd}}{1 \text{ mi}}$$

	SI	THESE ARE	
Distance	Angstrom unit cm in. ft yd km mi	10 ⁻¹⁰ 10 ⁻² 2.5400 × 10 ⁻² 0.30480 0.91440 10 ³ 1609.4	meter
Velocity	ft sec ⁻¹ mi hr ⁻¹	0.30480 0.44704	meter sec ⁻¹
Mass	gm slug lb (mass)	10 ⁻³ 14.594 0.45359	kilogram
Force and weight	dyne poundal lb (force)	10 ⁻⁵ 0.13826 4.4482	newton
Energy	erg kwh cal ft lb Btu	10 ⁻⁷ 3.6 × 10 ⁶ 4.182 1.356 1055	joule
Power	erg sec ⁻¹ cal sec ⁻¹ Btu hr ⁻¹	10 ⁻⁷ 4.182 0.2930	watt
Pressure	dyne cm ⁻² lb in ⁻² atm cm Hg	10 ⁻¹ 6.895 × 10 ⁴ 1.013 × 10 ⁵ 1333	newton m ⁻²
Density	gm cm ⁻³ lb ft ⁻³	10 ³ 16.018	kg m ⁻³
Specific heat	cal gm ⁻¹ deg ⁻¹ Btu lb ⁻¹ (°F) ⁻¹	4182 4182	joule kg ⁻¹ deg ⁻¹
Charge	statcoul (esu) abccoul (emu)	3.333 × 10 ⁻¹⁰ 10	coulomb
Electric field strength	volt cm ⁻¹ dyne statcoul ⁻¹ (esu)	10 ⁸ 3 × 10 ⁴	volt m ⁻¹

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80	37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9044	54 Xe 131.30	55 Cs 132.905	56 Ba 137.34	57 *La 138.91	58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)	87 Fr (223)	88 Ra (226)	89 *Ac (227)	90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (253)	103 Lw (257)	104 Uut (261)	105 Uub (262)	106 Uuq (263)	107 Uuh (264)	108 Uus (265)	109 Uuo (266)	110 Uut (267)	111 Uub (268)	112 Uuq (269)	113 Uuh (270)	114 Uus (271)	115 Uuo (272)	116 Uut (273)	117 Uub (274)	118 Uuq (275)	119 Uuh (276)	120 Uus (277)	121 Uuo (278)	122 Uut (279)	123 Uub (280)	124 Uuq (281)	125 Uuh (282)	126 Uus (283)	127 Uuo (284)	128 Uut (285)	129 Uub (286)	130 Uuq (287)	131 Uuh (288)	132 Uus (289)	133 Uuo (290)	134 Uut (291)	135 Uub (292)	136 Uuq (293)	137 Uuh (294)	138 Uus (295)	139 Uuo (296)	140 Uut (297)	141 Uub (298)	142 Uuq (299)	143 Uuh (300)	144 Uus (301)	145 Uuo (302)	146 Uut (303)	147 Uub (304)	148 Uuq (305)	149 Uuh (306)	150 Uus (307)	151 Uuo (308)	152 Uut (309)	153 Uub (310)	154 Uuq (311)	155 Uuh (312)	156 Uus (313)	157 Uuo (314)	158 Uut (315)	159 Uub (316)	160 Uuq (317)	161 Uuh (318)	162 Uus (319)	163 Uuo (320)	164 Uut (321)	165 Uub (322)	166 Uuq (323)	167 Uuh (324)	168 Uus (325)	169 Uuo (326)	170 Uut (327)	171 Uub (328)	172 Uuq (329)	173 Uuh (330)	174 Uus (331)	175 Uuo (332)	176 Uut (333)	177 Uub (334)	178 Uuq (335)	179 Uuh (336)	180 Uus (337)	181 Uuo (338)	182 Uut (339)	183 Uub (340)	184 Uuq (341)	185 Uuh (342)	186 Uus (343)	187 Uuo (344)	188 Uut (345)	189 Uub (346)	190 Uuq (347)	191 Uuh (348)	192 Uus (349)	193 Uuo (350)	194 Uut (351)	195 Uub (352)	196 Uuq (353)	197 Uuh (354)	198 Uus (355)	199 Uuo (356)	200 Uut (357)	201 Uub (358)	202 Uuq (359)	203 Uuh (360)	204 Uus (361)	205 Uuo (362)	206 Uut (363)	207 Uub (364)	208 Uuq (365)	209 Uuh (366)	210 Uus (367)	211 Uuo (368)	212 Uut (369)	213 Uub (370)	214 Uuq (371)	215 Uuh (372)	216 Uus (373)	217 Uuo (374)	218 Uut (375)	219 Uub (376)	220 Uuq (377)	221 Uuh (378)	222 Uus (379)	223 Uuo (380)	224 Uut (381)	225 Uub (382)	226 Uuq (383)	227 Uuh (384)	228 Uus (385)	229 Uuo (386)	230 Uut (387)	231 Uub (388)	232 Uuq (389)	233 Uuh (390)	234 Uus (391)	235 Uuo (392)	236 Uut (393)	237 Uub (394)	238 Uuq (395)	239 Uuh (396)	240 Uus (397)	241 Uuo (398)	242 Uut (399)	243 Uub (400)	244 Uuq (401)	245 Uuh (402)	246 Uus (403)	247 Uuo (404)	248 Uut (405)	249 Uub (406)	250 Uuq (407)	251 Uuh (408)	252 Uus (409)	253 Uuo (410)	254 Uut (411)	255 Uub (412)	256 Uuq (413)	257 Uuh (414)	258 Uus (415)	259 Uuo (416)	260 Uut (417)	261 Uub (418)	262 Uuq (419)	263 Uuh (420)	264 Uus (421)	265 Uuo (422)	266 Uut (423)	267 Uub (424)	268 Uuq (425)	269 Uuh (426)	270 Uus (427)	271 Uuo (428)	272 Uut (429)	273 Uub (430)	274 Uuq (431)	275 Uuh (432)	276 Uus (433)	277 Uuo (434)	278 Uut (435)	279 Uub (436)	280 Uuq (437)	281 Uuh (438)	282 Uus (439)	283 Uuo (440)	284 Uut (441)	285 Uub (442)	286 Uuq (443)	287 Uuh (444)	288 Uus (445)	289 Uuo (446)	290 Uut (447)	291 Uub (448)	292 Uuq (449)	293 Uuh (450)	294 Uus (451)	295 Uuo (452)	296 Uut (453)	297 Uub (454)	298 Uuq (455)	299 Uuh (456)	300 Uus (457)	301 Uuo (458)	302 Uut (459)	303 Uub (460)	304 Uuq (461)	305 Uuh (462)	306 Uus (463)	307 Uuo (464)	308 Uut (465)	309 Uub (466)	310 Uuq (467)	311 Uuh (468)	312 Uus (469)	313 Uuo (470)	314 Uut (471)	315 Uub (472)	316 Uuq (473)	317 Uuh (474)	318 Uus (475)	319 Uuo (476)	320 Uut (477)	321 Uub (478)	322 Uuq (479)	323 Uuh (480)	324 Uus (481)	325 Uuo (482)	326 Uut (483)	327 Uub (484)	328 Uuq (485)	329 Uuh (486)	330 Uus (487)	331 Uuo (488)	332 Uut (489)	333 Uub (490)	334 Uuq (491)	335 Uuh (492)	336 Uus (493)	337 Uuo (494)	338 Uut (495)	339 Uub (496)	340 Uuq (497)	341 Uuh (498)	342 Uus (499)	343 Uuo (500)	344 Uut (501)	345 Uub (502)	346 Uuq (503)	347 Uuh (504)	348 Uus (505)	349 Uuo (506)	350 Uut (507)	351 Uub (508)	352 Uuq (509)	353 Uuh (510)	354 Uus (511)	355 Uuo (512)	356 Uut (513)	357 Uub (514)	358 Uuq (515)	359 Uuh (516)	360 Uus (517)	361 Uuo (518)	362 Uut (519)	363 Uub (520)	364 Uuq (521)	365 Uuh (522)	366 Uus (523)	367 Uuo (524)	368 Uut (525)	369 Uub (526)	370 Uuq (527)	371 Uuh (528)	372 Uus (529)	373 Uuo (530)	374 Uut (531)	375 Uub (532)	376 Uuq (533)	377 Uuh (534)	378 Uus (535)	379 Uuo (536)	380 Uut (537)	381 Uub (538)	382 Uuq (539)	383 Uuh (540)	384 Uus (541)	385 Uuo (542)	386 Uut (543)	387 Uub (544)	388 Uuq (545)	389 Uuh (546)	390 Uus (547)	391 Uuo (548)	392 Uut (549)	393 Uub (550)	394 Uuq (551)	395 Uuh (552)	396 Uus (553)	397 Uuo (554)	398 Uut (555)	399 Uub (556)	400 Uuq (557)	401 Uuh (558)	402 Uus (559)	403 Uuo (560)	404 Uut (561)	405 Uub (562)	406 Uuq (563)	407 Uuh (564)	408 Uus (565)	409 Uuo (566)	410 Uut (567)	411 Uub (568)	412 Uuq (569)	413 Uuh (570)	414 Uus (571)	415 Uuo (572)	416 Uut (573)	417 Uub (574)	418 Uuq (575)	419 Uuh (576)	420 Uus (577)	421 Uuo (578)	422 Uut (579)	423 Uub (580)	424 Uuq (581)	425 Uuh (582)	426 Uus (583)	427 Uuo (584)	428 Uut (585)	429 Uub (586)	430 Uuq (587)	431 Uuh (588)	432 Uus (589)	433 Uuo (590)	434 Uut (591)	435 Uub (592)	436 Uuq (593)	437 Uuh (594)	438 Uus (595)	439 Uuo (596)	440 Uut (597)	441 Uub (598)	442 Uuq (599)	443 Uuh (600)	444 Uus (601)	445 Uuo (602)	446 Uut (603)	447 Uub (604)	448 Uuq (605)	449 Uuh (606)	450 Uus (607)	451 Uuo (608)	452 Uut (609)	453 Uub (610)	454 Uuq (611)	455 Uuh (612)	456 Uus (613)	457 Uuo (614)	458 Uut (615)	459 Uub (616)	460 Uuq (617)	461 Uuh (618)	462 Uus (619)	463 Uuo (620)	464 Uut (621)	465 Uub (622)	466 Uuq (623)	467 Uuh (624)	468 Uus (625)	469 Uuo (626)	470 Uut (627)	471 Uub (628)	472 Uuq (629)	473 Uuh (630)	474 Uus (631)	475 Uuo (632)	476 Uut (633)	477 Uub (634)	478 Uuq (635)	479 Uuh (636)	480 Uus (637)	481 Uuo (638)	482 Uut (639)	483 Uub (640)	484 Uuq (641)	485 Uuh (642)	486 Uus (643)	487 Uuo (644)	488 Uut (645)	489 Uub (646)	490 Uuq (647)	491 Uuh (648)	492 Uus (649)	493 Uuo (650)	494 Uut (651)	495 Uub (652)	496 Uuq (653)	497 Uuh (654)	498 Uus (655)	499 Uuo (656)	500 Uut (657)	501 Uub (658)	502 Uuq (659)	503 Uuh (660)	504 Uus (661)	505 Uuo (662)	506 Uut (663)	507 Uub (664)	508 Uuq (665)	509 Uuh (666)	510 Uus (667)	511 Uuo (668)	512 Uut (669)	513 Uub (670)	514 Uuq (671)	515 Uuh (672)	516 Uus (673)	517 Uuo (674)	518 Uut (675)	519 Uub (676)	520 Uuq (677)	521 Uuh (678)	522 Uus (679)	523 Uuo (680)	524 Uut (681)	525 Uub (682)	526 Uuq (683)	527 Uuh (684)	528 Uus (685)	529 Uuo (686)	530 Uut (687)	531 Uub (688)	532 Uuq (689)	533 Uuh (690)	534 Uus <

10 — Common Logarithms of Numbers — 54

N	Prop. Parts										N
	0	1	2	3	4	5	6	7	8	9	
10	0 000	043	086	128	170	212	253	294	334	374	10
11	414	453	492	531	569	607	645	682	719	755	11
12	0 792	828	864	899	934	969	004	039	072	106	12
13	1 139	173	206	239	271	303	335	367	399	430	13
14	461	492	523	553	584	614	644	673	703	732	14
15	1 761	790	818	847	875	903	931	959	987	014	15
16	2 041	068	095	122	148	175	201	227	253	279	16
17	304	330	355	380	405	430	455	480	504	529	17
18	553	577	601	625	648	672	695	718	742	765	18
19	2 788	810	833	856	878	900	923	945	967	989	19
20	3 010	032	054	075	096	118	139	160	181	201	20
21	222	243	263	284	304	324	345	365	385	404	21
22	424	444	464	483	502	522	541	560	579	598	22
23	617	636	655	674	692	711	729	747	765	784	23
24	802	820	838	856	874	892	909	927	945	962	24
25	3 979	997	014	031	048	065	082	099	116	133	25
26	4 150	166	183	200	216	232	249	265	281	298	26
27	314	330	346	362	378	393	409	425	440	456	27
28	472	487	502	518	533	548	564	579	594	609	28
29	624	639	654	669	683	698	713	728	742	757	29
30	4 771	786	800	814	829	843	857	871	886	900	30
31	4 914	928	942	955	969	983	997	011	024	038	31
32	5 051	065	079	092	105	119	132	145	159	172	32
33	185	198	211	224	237	250	263	276	289	302	33
34	315	328	340	353	366	378	391	403	416	428	34
35	441	453	465	478	490	502	514	527	539	551	35
36	563	575	587	599	611	623	635	647	658	670	36
37	682	694	705	717	729	740	752	763	775	786	37
38	798	809	821	832	843	855	866	877	888	899	38
39	5 911	922	933	944	955	966	977	988	999	010	39
40	6 021	031	042	053	064	075	085	096	107	117	40
41	128	138	149	160	170	180	191	201	212	222	41
42	232	243	253	263	274	284	294	304	314	325	42
43	335	345	355	365	375	385	395	405	415	425	43
44	435	444	454	464	474	484	493	503	513	522	44
45	532	542	551	561	571	580	590	599	609	618	45
46	628	637	646	656	665	675	684	693	702	712	46
47	721	730	739	749	758	767	776	785	794	803	47
48	812	821	830	839	848	857	866	875	884	893	48
49	902	911	920	928	937	946	955	964	972	981	49
50	6 990	998	007	016	024	033	042	050	059	067	50
51	7 076	084	093	101	110	118	126	135	143	152	51
52	160	168	177	185	193	202	210	218	226	235	52
53	243	251	259	267	275	284	292	300	308	316	53
54	7 324	332	340	348	356	364	372	380	388	396	54
N	Prop. Parts										N
	0	1	2	3	4	5	6	7	8	9	
1	0	1	2	3	4	5	6	7	8	9	1
2	30	60	90	120	150	180	210	240	270	300	2
3	477	854	1231	1607	1983	2359	2735	3111	3487	3863	3
4	602	1204	1806	2408	3010	3612	4214	4816	5418	6020	4
5	753	1506	2259	3012	3765	4518	5271	6024	6777	7530	5
6	931	1862	2793	3724	4655	5586	6517	7448	8379	9310	6
7	1141	2282	3423	4564	5705	6846	7987	9128	0269	1410	7
8	1386	2772	4158	5544	6930	8316	9702	10888	2224	3610	8
9	1664	3328	4992	6656	8320	9984	11648	23296	40000	56704	9
10	1976	3952	5928	7904	9880	11856	23712	43472	63232	82992	10
20	3010	6020	9030	12040	15050	18060	21070	24080	27090	30100	20
30	4771	9542	14313	19084	23855	28626	33397	38168	42939	47710	30
40	6021	12042	18063	24084	30105	36126	42147	48168	54189	60210	40
50	7531	15062	22593	30124	37655	45186	52717	60248	67779	75310	50
60	9311	18622	27933	37244	46555	55866	65177	74488	83799	93110	60
70	11411	22822	34233	45644	57055	68466	79877	91288	02699	14110	70
80	13861	27722	41583	55444	69305	83166	97027	108888	22249	36110	80
90	16641	33282	49923	66564	83205	99846	11647	23298	40000	56704	90
100	19761	39522	59283	79044	98805	11856	23717	43478	63238	82999	100

55 — Common Logarithms of Numbers — 99

Prop. Parts											
N	0	1	2	3	4	5	6	7	8	9	N
55	7 404	412	419	427	435	443	451	459	466	474	55
56	482	490	497	505	513	520	528	536	543	551	56
57	559	566	574	582	589	597	604	612	619	627	57
58	634	642	649	657	664	672	679	686	694	701	58
59	709	716	723	731	738	745	752	760	767	774	59
60	782	789	796	803	810	818	825	832	839	846	60
61	853	860	868	875	882	889	896	903	910	917	61
62	924	931	938	945	952	959	966	973	980	987	62
63	7 993	000	007	014	021	028	035	041	048	055	63
64	8 062	069	075	082	089	096	102	109	116	122	64
65	129	136	142	149	156	162	169	176	182	189	65
66	195	202	209	215	222	228	235	241	248	254	66
67	261	267	274	280	287	293	299	306	312	319	67
68	325	331	338	344	351	357	363	370	376	382	68
69	388	395	401	407	414	420	426	432	439	445	69
70	451	457	463	470	476	482	488	494	500	506	70
71	513	519	525	531	537	543	549	555	561	567	71
72	573	579	585	591	597	603	609	615	621	627	72
73	633	639	645	651	657	663	669	675	681	686	73
74	692	698	704	710	716	722	727	733	739	745	74
75	751	756	762	768	774	779	785	791	797	802	75
76	808	814	820	825	831	837	842	848	854	859	76
77	865	871	876	882	887	893	899	904	910	915	77
78	921	927	932	938	943	949	954	960	965	971	78
79	976	982	987	993	998	004	009	015	020	025	79
80	9 031	036	042	047	053	058	063	069	074	079	80
81	085	090	096	101	106	112	117	122	128	133	81
82	138	143	149	154	159	165	170	175	180	186	82
83	191	196	201	206	212	217	222	227	232	238	83
84	243	248	253	258	263	269	274	279	284	289	84
85	294	299	304	309	315	320	325	330	335	340	85
86	345	350	355	360	365	370	375	380	385	390	86
87	395	400	405	410	415	420	425	430	435	440	87
88	445	450	455	460	465	469	474	479	484	489	88
89	494	499	504	509	513	518	523	528	533	538	89
90	542	547	552	557	562	566	571	576	581	586	90
91	590	595	600	605	609	614	619	624	628	633	91
92	638	643	647	652	657	661	666	671	675	680	92
93	685	689	694	699	703	708	713	717	722	727	93
94	731	736	741	745	750	754	759	763	768	773	94
95	777	782	786	791	795	800	805	809	814	818	95
96	823	827	832	836	841	845	850	854	859	863	96
97	868	872	877	881	886	890	894	899	903	908	97
98	912	917	921	926	930	934	939	943	948	952	98
99	956	961	965	969	974	978	983	987	991	996	99

Prop. Parts											
N	0	1	2	3	4	5	6	7	8	9	N
1	0	1	2	3	4	5	6	7	8	9	1
2	30	60	90	120	150	180	210	240	270	300	2
3	477	854	1231	1607	1983	2359	2735	3111	3487	3863	3
4	602	1204	1806	2408	3010	3612	4214	4816	5418	6020	4
5	727	1454	2181	2807	3433	4059	4685	5311	5937	6563	5
6	852	1704	2556	3308	4060	4812	5564	6316	7068	7820	6
7	977	1954	2931	3807	4683	5559	6435	7311	8187	9063	7
8	1102	2204	3306	4308	5310	6312	7314	8316	9318	10320	8
9	1227	2454	3681	4807	5933	7059	8185	9311	10437	11563	9

Prop. Parts											
N	0	1	2	3	4	5	6	7	8	9	N
1	0	1	2	3	4	5	6	7	8	9	1
2	30	60	90	120	150	180	210	240	270	300	2
3	477	854	1231	1607	1983	2359	2735	3111	3487	3863	3
4	602	1204	1806	2408	3010	3612	4214	4816	5418	6020	4
5	727	1454	2181	2807	3433	4059	4685	5311	5937	6563	5
6	852	1704	2556	3308	4060	4812	5564	6316	7068	7820	6
7	977	1954	2931	3807	4683	5559	6435	7311	8187	9063	7
8	1102	2204	3306	4308	5310	6312	7314	8316	9318	10320	8
9	1227	2454	3681	4807	5933	7059	8185	9311	10437	11563	9

SAN DIEGO CITY SCHOOLS
Curriculum Services Division

Trigonometry Table - Four-Place Values of Functions and Radians

DEGREES	RADIANS	Sin	Cos	Tan	Cot	90° 00'
0° 00'	.0000	.0000	1.0000	.0000	—	1.5708
10	.0175	.0175	.9988	.0175	57.29	1.5533
20	.0349	.0349	.9984	.0349	28.64	1.5359
30	.0524	.0524	.9986	.0524	19.08	1.5184
40	.0698	.0698	.9976	.0698	14.30	1.5010
50	.0873	.0873	.9952	.0875	11.43	1.4835
60	.1047	.1045	.9915	.1051	9.514	1.4661
70	.1222	.1219	.9863	.1225	8.144	1.4486
80	.1396	.1392	.9793	.1405	7.115	1.4312
90	.1571	.1564	.9707	.1584	6.314	1.4137
100	.1745	.1736	.9608	6.314	1.3963	1.3963
110	.1919	.1908	.9500	6.314	1.3788	1.3788
120	.2093	.2079	.9373	6.314	1.3614	1.3614
130	.2267	.2250	.9228	6.314	1.3439	1.3439
140	.2441	.2419	.9073	6.314	1.3265	1.3265
150	.2615	.2588	.8908	6.314	1.3090	1.3090
160	.2789	.2756	.8733	6.314	1.2915	1.2915
170	.2963	.2924	.8548	6.314	1.2741	1.2741
180	.3137	.3090	.8354	6.314	1.2566	1.2566
190	.3311	.3258	.8151	6.314	1.2391	1.2391
200	.3485	.3426	.7939	6.314	1.2217	1.2217
210	.3659	.3594	.7717	6.314	1.2043	1.2043
220	.3833	.3762	.7486	6.314	1.1868	1.1868
230	.4007	.3931	.7246	6.314	1.1694	1.1694
240	.4181	.4100	.6997	6.314	1.1519	1.1519
250	.4355	.4268	.6740	6.314	1.1345	1.1345
260	.4529	.4437	.6476	6.314	1.1170	1.1170
270	.4703	.4606	.6205	6.314	1.1000	1.1000
280	.4877	.4775	.5928	6.314	1.0833	1.0833
290	.5051	.4945	.5646	6.314	1.0670	1.0670
300	.5225	.5115	.5357	6.314	1.0510	1.0510
310	.5400	.5285	.5062	6.314	1.0353	1.0353
320	.5574	.5455	.4761	6.314	1.0199	1.0199
330	.5749	.5625	.4455	6.314	1.0048	1.0048
340	.5923	.5795	.4145	6.314	.9899	.9899
350	.6098	.5963	.3830	6.314	.9752	.9752
360	.6272	.6133	.3502	6.314	.9607	.9607
370	.6446	.6303	.3171	6.314	.9464	.9464
380	.6620	.6473	.2837	6.314	.9322	.9322
390	.6794	.6656	.2499	6.314	.9182	.9182
400	.6968	.6836	.2158	6.314	.9043	.9043
410	.7142	.7016	.1814	6.314	.8905	.8905
420	.7316	.7196	.1467	6.314	.8768	.8768
430	.7490	.7375	.1118	6.314	.8632	.8632
440	.7664	.7555	.0767	6.314	.8497	.8497
450	.7838	.7734	.0414	6.314	.8363	.8363
460	.8012	.7913	.0059	6.314	.8230	.8230
470	.8186	.8092	.0000	6.314	.8098	.8098
480	.8360	.8271	.0000	6.314	.7967	.7967
490	.8534	.8427	.0000	6.314	.7837	.7837
500	.8708	.8606	.0000	6.314	.7708	.7708
510	.8882	.8785	.0000	6.314	.7580	.7580
520	.9056	.8960	.0000	6.314	.7453	.7453
530	.9230	.9139	.0000	6.314	.7327	.7327
540	.9404	.9318	.0000	6.314	.7202	.7202
550	.9578	.9497	.0000	6.314	.7078	.7078
560	.9752	.9676	.0000	6.314	.6955	.6955
570	.9926	.9855	.0000	6.314	.6833	.6833
580	.1000	.9988	.0000	6.314	.6712	.6712
590	.1074	.9976	.0000	6.314	.6592	.6592
600	.1148	.9963	.0000	6.314	.6473	.6473
610	.1222	.9949	.0000	6.314	.6355	.6355
620	.1296	.9934	.0000	6.314	.6238	.6238
630	.1370	.9918	.0000	6.314	.6122	.6122
640	.1444	.9901	.0000	6.314	.6007	.6007
650	.1518	.9884	.0000	6.314	.5893	.5893
660	.1592	.9866	.0000	6.314	.5780	.5780
670	.1666	.9848	.0000	6.314	.5668	.5668
680	.1740	.9829	.0000	6.314	.5557	.5557
690	.1814	.9810	.0000	6.314	.5447	.5447
700	.1888	.9790	.0000	6.314	.5338	.5338
710	.1962	.9770	.0000	6.314	.5230	.5230
720	.2036	.9750	.0000	6.314	.5123	.5123
730	.2110	.9729	.0000	6.314	.5017	.5017
740	.2184	.9708	.0000	6.314	.4912	.4912
750	.2258	.9687	.0000	6.314	.4808	.4808
760	.2332	.9665	.0000	6.314	.4705	.4705
770	.2406	.9643	.0000	6.314	.4603	.4603
780	.2480	.9621	.0000	6.314	.4502	.4502
790	.2554	.9599	.0000	6.314	.4402	.4402
800	.2628	.9577	.0000	6.314	.4303	.4303
810	.2702	.9555	.0000	6.314	.4205	.4205
820	.2776	.9533	.0000	6.314	.4108	.4108
830	.2850	.9511	.0000	6.314	.4012	.4012
840	.2924	.9489	.0000	6.314	.3917	.3917
850	.3000	.9466	.0000	6.314	.3823	.3823
860	.3074	.9443	.0000	6.314	.3730	.3730
870	.3148	.9420	.0000	6.314	.3638	.3638
880	.3222	.9397	.0000	6.314	.3547	.3547
890	.3296	.9374	.0000	6.314	.3457	.3457
900	.3370	.9351	.0000	6.314	.3368	.3368
910	.3444	.9328	.0000	6.314	.3280	.3280
920	.3518	.9304	.0000	6.314	.3193	.3193
930	.3592	.9280	.0000	6.314	.3107	.3107
940	.3666	.9256	.0000	6.314	.3022	.3022
950	.3740	.9232	.0000	6.314	.2938	.2938
960	.3814	.9208	.0000	6.314	.2855	.2855
970	.3888	.9184	.0000	6.314	.2772	.2772
980	.3962	.9160	.0000	6.314	.2690	.2690
990	.4036	.9136	.0000	6.314	.2609	.2609
1000	.4110	.9112	.0000	6.314	.2529	.2529

DEGREES	RADIANS	Sin	Cos	Tan	Cot	
9° 00'	.1571	.1564	.9877	.1584	6.314	81° 00'
10	.600	.593	.872	.614	197	50
20	.629	.622	.868	.644	684	40
30	.1658	.1650	.9863	.1673	5.976	1.4050
40	.687	.679	.858	.703	871	1.4021
50	.716	.708	.853	.733	769	992
10° 00'	.1745	.1736	.9848	.1763	5.671	80° 00'
10	.774	.765	.843	.793	576	934
20	.804	.794	.838	.823	485	904
30	.1833	.1822	.9833	.1853	5.396	1.3875
40	.862	.851	.827	.883	399	846
50	.891	.880	.822	.914	226	817
11° 00'	.1920	.1908	.9816	.1944	5.145	79° 00'
10	.949	.937	.811	.974	666	759
20	.978	.965	.805	.2004	4.989	730
30	.2007	.1994	.9799	.2035	4.915	1.3701
40	.936	.922	.793	.985	843	672
50	.965	.951	.787	.995	773	643
12° 00'	.2094	.2079	.9781	.2126	4.705	78° 00'
10	.123	.108	.775	.156	638	584
20	.153	.136	.769	.186	574	555
30	.2182	.2164	.9763	.2217	4.511	1.3526
40	.211	.193	.757	.247	449	497
50	.240	.221	.750	.278	390	468
13° 00'	.2269	.2250	.9744	.2309	4.331	77° 00'
10	.298	.278	.737	.339	275	410
20	.327	.306	.730	.370	219	381
30	.2356	.2334	.9724	.2401	4.165	1.3352
40	.385	.363	.717	.432	113	323
50	.414	.391	.710	.462	661	294
14° 00'	.2443	.2419	.9703	.2493	4.011	76° 00'
10	.473	.447	.696	.524	3.962	235
20	.502	.476	.689	.555	914	206
30	.2531	.2504	.9681	.2586	3.867	1.3177
40	.560	.532	.674	.617	821	148
50	.589	.560	.667	.648	776	119
15° 00'	.2618	.2588	.9659	.2679	3.732	75° 00'
10	.647	.616	.652	.711	689	061
20	.676	.644	.644	.742	647	032
30	.2705	.2672	.9636	.2773	3.606	1.3003
40	.734	.700	.628	.805	566	974
50	.763	.728	.621	.836	526	945
16° 00'	.2793	.2756	.9613	.2867	3.487	74° 00'
10	.822	.784	.605	.889	450	586
20	.851	.812	.596	.931	412	857
30	.2880	.2840	.9588	.2962	3.376	1.2828
40	.909	.868	.580	.994	340	796
50	.938	.896	.572	.3026	305	770
17° 00'	.2967	.2924	.9563	.3057	3.271	73° 00'
10	.996	.952	.555	.989	237	712
20	.3025	.2979	.546	121	204	683
30	.3054	.3007	.9537	.3153	3.172	1.2654
40	.983	.935	.528	185	140	625
50	.113	.062	.520	217	108	595
18° 00'	.3142	.3090	.9511	.3249	3.078	72° 00'
		Cos	Sin	Cot	Tan	DEGREES

DEGREES	RADIANS	Sin	Cos	Tan	Cot	RADIANS	DEGREES
29° 00'	.4712	.4540	.8910	.5095	1.963	1.0996	63° 00'
10	.741	.566	.897	.132	.949	.966	50
20	.771	.592	.884	.169	.935	.937	40
30	.800	.617	.8870	.206	.921	1.0908	30
40	.829	.643	.857	.243	.907	.879	20
50	.858	.669	.843	.280	.894	.850	10
29° 00'	.4887	.4605	.8829	.5317	1.881	1.0821	62° 00'
10	.916	.720	.816	.354	.868	.792	50
20	.945	.746	.802	.392	.855	.763	40
30	.974	.772	.8788	.430	.842	1.0734	30
40	.5003	.797	.774	.467	.829	.705	20
50	.5032	.823	.760	.505	.816	.676	10
29° 00'	.5061	.4848	.8746	.5543	1.804	1.0647	61° 00'
10	.091	.874	.732	.581	.792	.617	50
20	.120	.899	.718	.619	.780	.588	40
30	.149	.924	.8704	.658	.767	1.0559	30
40	.178	.950	.689	.696	.756	.530	20
50	.207	.975	.675	.735	.744	.501	10
29° 00'	.5236	.5000	.8660	.5774	1.732	1.0472	60° 00'
10	.265	.025	.646	.812	.720	.443	50
20	.294	.050	.631	.851	.709	.414	40
30	.323	.075	.8616	.890	1.698	1.0385	30
40	.352	.100	.601	.930	.686	.356	20
50	.381	.125	.587	.969	.675	.327	10
29° 00'	.5411	.5150	.8572	.6009	1.664	1.0297	59° 00'
10	.440	.175	.557	.048	.653	.268	50
20	.469	.200	.542	.088	.643	.239	40
30	.498	.5225	.8526	.6128	1.632	1.0210	30
40	.527	.250	.511	.168	.621	.181	20
50	.556	.275	.496	.208	.611	.152	10
29° 00'	.5585	.5299	.8480	.6249	1.600	1.0123	58° 00'
10	.614	.324	.465	.289	.590	.094	50
20	.643	.348	.450	.330	.580	.065	40
30	.5672	.5373	.8434	.6371	1.570	1.0036	30
40	.701	.398	.418	.412	.560	1.0007	20
50	.730	.422	.403	.453	.550	.977	10
29° 00'	.5760	.5446	.8387	.6494	1.540	.9948	57° 00'
10	.789	.471	.371	.536	.530	.919	50
20	.818	.495	.355	.577	.520	.890	40
30	.5847	.5519	.8339	.6619	1.511	.9861	30
40	.876	.544	.323	.661	.501	.832	20
50	.905	.568	.307	.703	1.492	.803	10
29° 00'	.5934	.5592	.8200	.6745	1.483	.9774	56° 00'
10	.963	.616	.274	.787	.473	.745	50
20	.992	.640	.258	.830	.464	.716	40
30	.6021	.5664	.8241	.6873	1.455	.9687	30
40	.050	.688	.225	.916	.446	.657	20
50	.080	.712	.208	.959	.437	.628	10
29° 00'	.6109	.5736	.8192	.7002	1.428	.9599	55° 00'
10	.138	.760	.175	.046	.419	.570	50
20	.167	.783	.158	.089	.411	.541	40
30	.6196	.5807	.8141	.7133	1.402	.9512	30
40	.225	.831	.124	.177	.393	.483	20
50	.254	.854	.107	.221	.385	.454	10
29° 00'	.6283	.5878	.8090	.7265	1.376	.9425	54° 00'

DEGREES	RADIANS	Sin	Cos	Tan	Cot	RADIANS	DEGREES
36° 00'	.6283	.5878	.8090	.7265	1.376	.9425	54° 00'
10	.312	.901	.073	.310	.368	.396	50
20	.341	.925	.056	.335	.360	.367	40
30	.6370	.5948	.8039	.7400	1.351	.9338	30
40	.400	.972	.021	.445	.343	.308	20
50	.429	.995	.004	.490	.335	.279	10
37° 00'	.6458	.6018	.7986	.7336	1.327	.9250	53° 00'
10	.487	.041	.909	.581	.319	.221	50
20	.516	.065	.951	.627	.311	.192	40
30	.6543	.6088	.7934	.7073	1.303	.9163	30
40	.574	.111	.916	.720	.295	.134	20
50	.603	.134	.898	.766	.288	.105	10
38° 00'	.6632	.6157	.7880	.7813	1.280	.9076	52° 00'
10	.661	.180	.862	.800	.272	.047	50
20	.690	.202	.844	.907	.265	.9018	40
30	.6720	.6225	.7856	.7954	1.257	.8988	30
40	.749	.248	.808	.8002	.250	.959	20
50	.778	.271	.790	.830	.242	.930	10
39° 00'	.6807	.6293	.7771	.8098	1.235	.8901	51° 00'
10	.836	.316	.753	.146	.228	.872	50
20	.865	.338	.735	.193	.220	.843	40
30	.6894	.6361	.7716	.8243	1.213	.8814	30
40	.923	.383	.698	.292	.206	.785	20
50	.952	.406	.679	.342	.199	.756	10
40° 00'	.6981	.6428	.7660	.8391	1.192	.8727	50° 00'
10	.7010	.450	.642	.441	.185	.698	50
20	.039	.472	.623	.491	.178	.668	40
30	.7069	.6494	.7604	.8541	1.171	.8639	30
40	.098	.517	.585	.591	.164	.610	20
50	.127	.539	.566	.642	.157	.581	10
41° 00'	.7156	.6561	.7547	.8693	1.150	.8552	49° 00'
10	.185	.583	.528	.744	.144	.523	50
20	.214	.604	.500	.796	.137	.494	40
30	.7243	.6626	.7490	.8847	1.130	.8465	30
40	.272	.648	.470	.899	.124	.436	20
50	.301	.670	.451	.952	.117	.407	10
42° 00'	.7330	.6691	.7431	.9004	1.111	.8378	48° 00'
10	.359	.713	.412	.057	.104	.348	50
20	.389	.734	.392	.110	.098	.319	40
30	.7418	.6756	.7373	.9163	1.091	.8290	30
40	.447	.777	.353	.217	.085	.261	20
50	.476	.799	.333	.271	.079	.232	10
43° 00'	.7505	.6820	.7314	.9325	1.072	.8203	47° 00'
10	.534	.841	.294	.380	.066	.174	50
20	.563	.862	.274	.435	.060	.145	40
30	.7592	.6884	.7254	.9490	1.054	.8116	30
40	.621	.905	.234	.545	.048	.087	20
50	.650	.926	.214	.601	.042	.058	10
44° 00'	.7679	.6947	.7193	.9637	1.036	.8029	46° 00'
10	.709	.967	.173	.713	.030	.999	50
20	.738	.988	.153	.770	.024	.970	40
30	.7767	.7009	.7133	.9827	1.018	.7941	30
40	.796	.030	.112	.884	.012	.912	20
50	.825	.050	.092	.942	.006	.883	10
45° 00'	.7854	.7071	.7071	1.000	1.000	.7854	45° 00'